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FINAL SUBMITTAL

ENERGY SURVEYS OF ARMY INDUSTRIAL FACILITIES ENERGY ENGINEERING ANALYSIS PROGRAM RADFORD ARMY AMMUNITION PLANT RADFORD, VIRGINIA

VOLUME I

NARRATIVE REPORT

89
CONTRACT NO. DACA65-[redacted]-C-0154

PREPARED FOR:

U.S. ARMY CORPS OF ENGINEERS
NORFOLK, VIRGINIA

PREPARED BY:

ENERGY AND ENVIRONMENTAL SERVICES DEPARTMENT
REYNOLDS, SMITH AND HILLS, INC.
P.O. BOX 4850
JACKSONVILLE, FLORIDA 32201

MARCH 1991

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
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ENERGY SURVEYS OF
ARMY INDUSTRIAL FACILITIES
ENERGY ENGINEERING ANALYSIS PROGRAM
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

1.1 Purpose

In October 1989, the Corps of Engineers, Norfolk District, issued Contract No. DACA65-89-C-0154 with Hunter Services, Inc. of Jacksonville, Florida. This contract called for the performance of Energy Engineering Analysis Program (EEAP) studies of Army Industrial Facilities at Radford Army Ammunition Plant (RAAP), Radford, Virginia. The objective of this study is to identify, evaluate and develop energy saving projects which meet the criteria of the army's many energy funding programs.

1.2 Report Organization

The report consists of an Executive Summary and four volumes. Volume I, the Narrative Report, contains the results of all of the site surveys, analysis and project development. All backup data and calculations are found in Volume II. The site survey notes are in Volume III, and project documentation forms necessary for receiving funding are in Volume IV.

2.0 INSTALLATION DESCRIPTION

Radford Army Ammunition Plant is located just north of I-81, 37 miles southwest of Roanoke and 108 miles northeast of Bristol, Tennessee. The facility was built in 1941 and was the first to produce gun powder in the U.S. Government's defense plant program. This was the first creation of the GOCO (government-owned, contractor-operated) plant, dedicated wholly to the production of war material. Since 1941, RAAP has produced over two billion pounds of military propellants in such areas as:

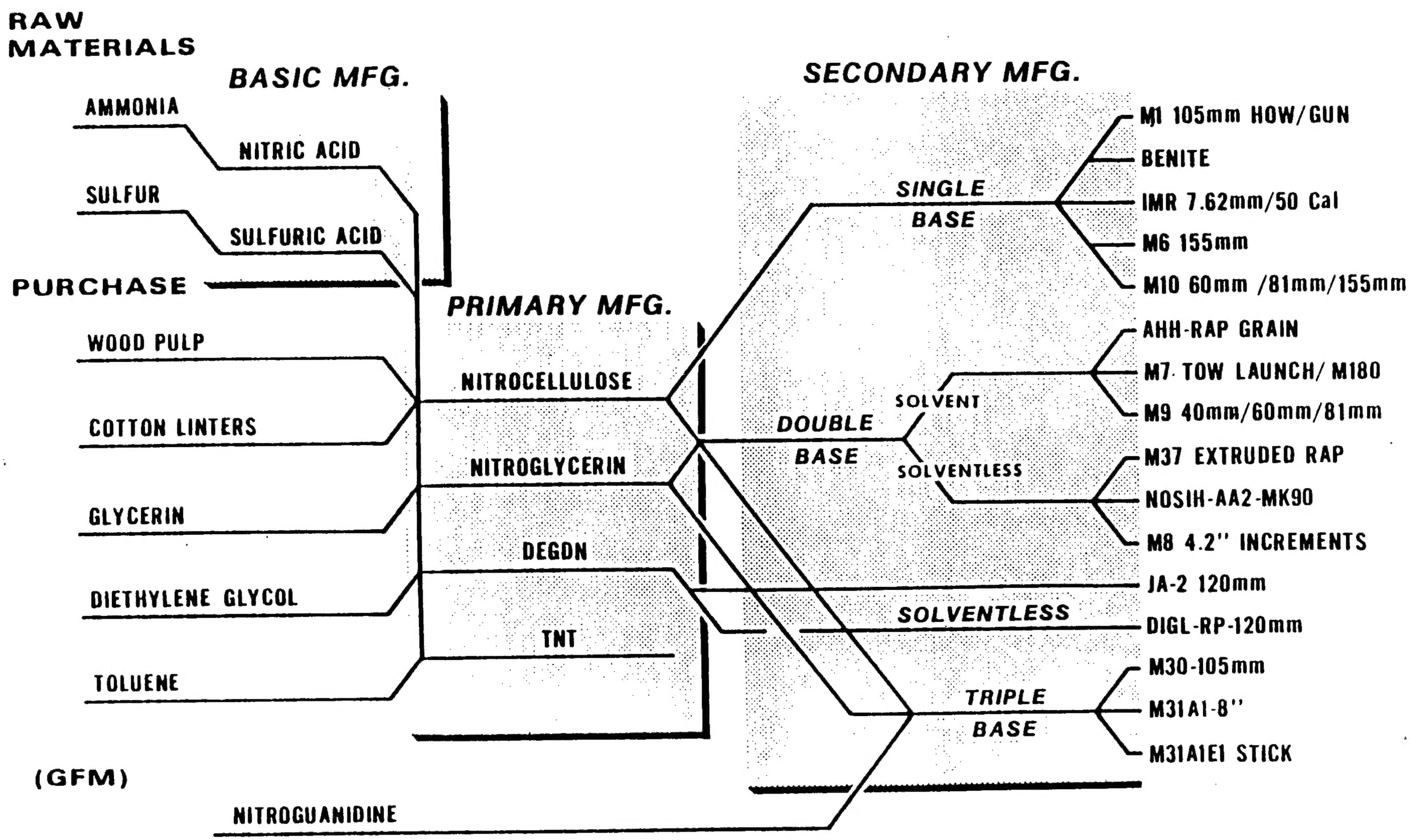
- Rockets
- Single-Base Propellants
- Solventless Propellants
- Double-Base Propellants
- Triple-Base Propellants
- Ignitors
- TNT
- Mortar Increments

Figure 2-1 contains a base materials flow diagram.

The RAAP installation includes approximately 7,000 acres and over 1,200 buildings. The employment level as in September 1989 was 5,350. Figure 2-2 is a site plan of RAAP and describes the basic production areas. Areas covered under this scope of work are:

Acid	Cast Propellant
Nitrocellulose B & C	Extruded Propellant
Solvent Recovery	Multibase Finishing
Finishing	Plant Air
Solventless	Plant Water
Increment 1	Powerhouses 1 & 2

BASE MATERIALS FLOW DIAGRAM
FOR PROPELLANTS MANUFACTURED AT RAAP



ONLY A SAMPLE OF PROPELLANTS SHOWN

FIGURE 2-1

RADFORD UNIT

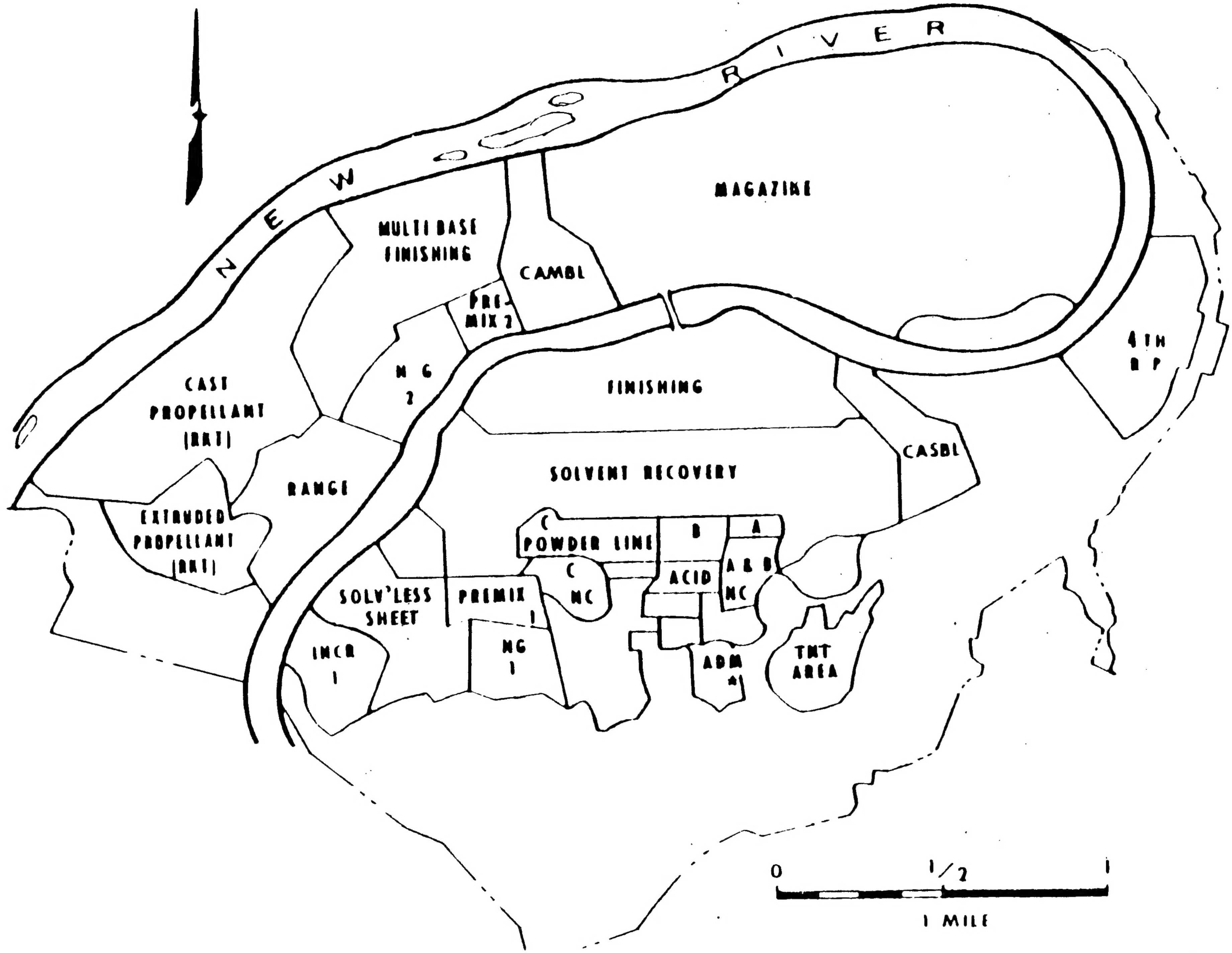


FIGURE 2-2

Nitroglycerin 1 & 2

Premix 1 & 2

4th Rolled Powder

Inert Gas

Incinerators

Areas not included in the scope of work are:

Magazine

CAMBL

CASBL

TNT

Administration

Nitrocellulose A

3.0 ENERGY CONSUMPTION AND PRODUCTION DATA

3.1 Historical Energy Use

Figure 3-1 shows the energy use and cost at RAAP from fiscal years 1985 to 1989. Both energy use and cost display a downward trend. This correlates well with decreased nitrocellulose production rates over the same time period (Figure 3-2).

Figures 3-3 and 3-4 show the distribution of energy use and cost, respectively, by fuel type. Coal dominates both pie charts at 87 percent on a Btu basis and 61 percent of the total utility bill. RAAP purchases over $4,500,000 in coal annually and is probably the single largest coal consumer among U.S. Army installations! RAAP is also one of the few installations that generates its own electricity. Typically, RAAP generates about one-half of its electricity. However, power house incidents in FY 89 have temporarily halted electrical power generation during CY-1989 and CY-1990. Current power generation levels are temporarily reduced until Power House modifications are completed.

Average energy prices are shown in Figure 3-5. RAAP is fortunate that their two largest energy sources, electricity and coal are relatively inexpensive. Electricity is about one-half the price of the average U.S. Army installation. Also, most installations pay more than twice the $1.61/MBtu price for heating fuel, usually in the form of fuel oil or natural gas.

RAAP also has an extensive metering program. There are more than 80 electricity meters and steam use meters throughout the installation. Plant personnel use these meter readings to allocate energy use in the different production areas and also to determine if energy consumption or energy costs can be reduced. An analysis of these data was performed to estimate where the energy is used at RAAP. Fuel use amounts were analyzed and assigned to one of

Radford Army Ammunition Plant

Historical Energy Use & Cost

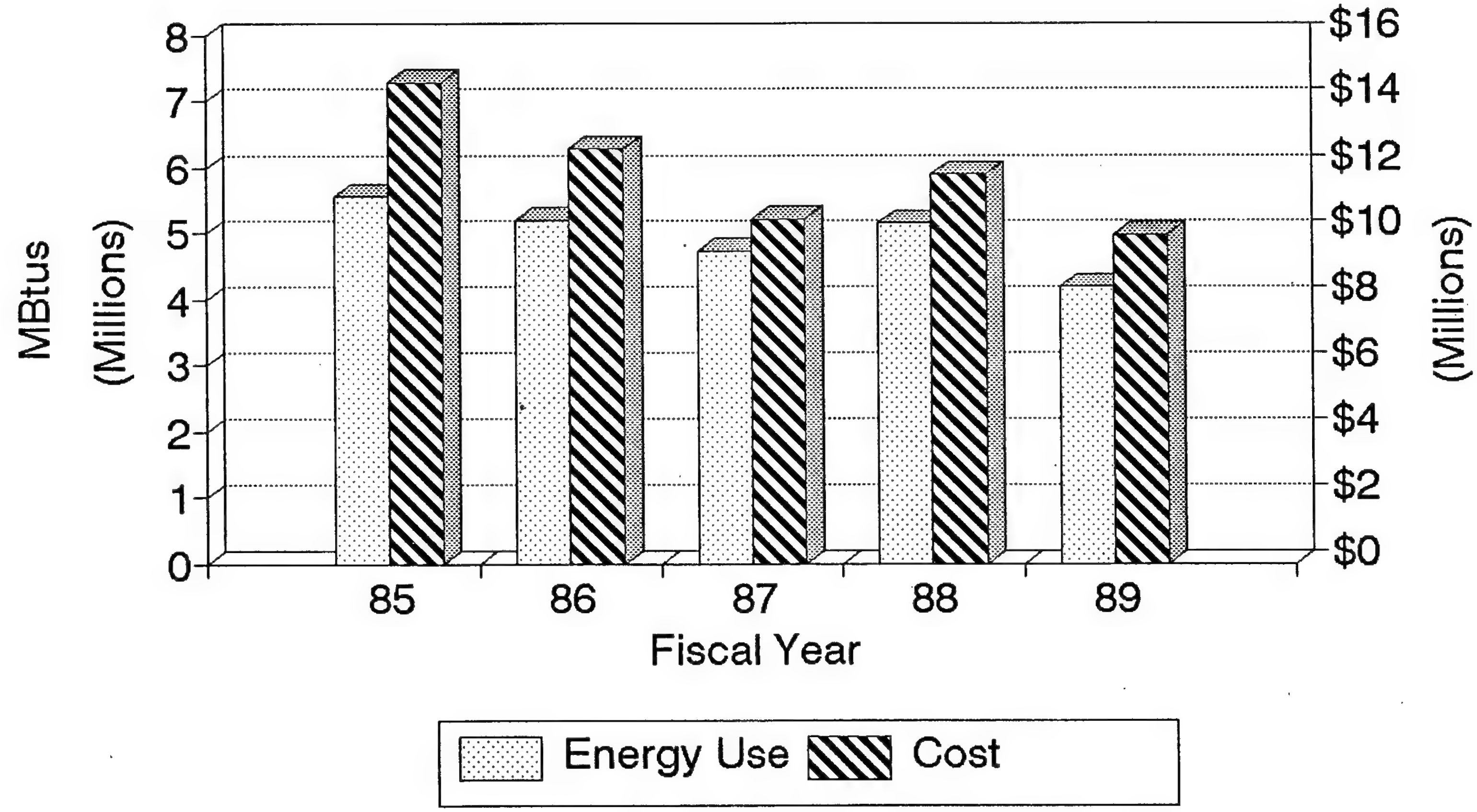


Figure 3-1

Radford Army Ammunition Plant
Historical NC Production

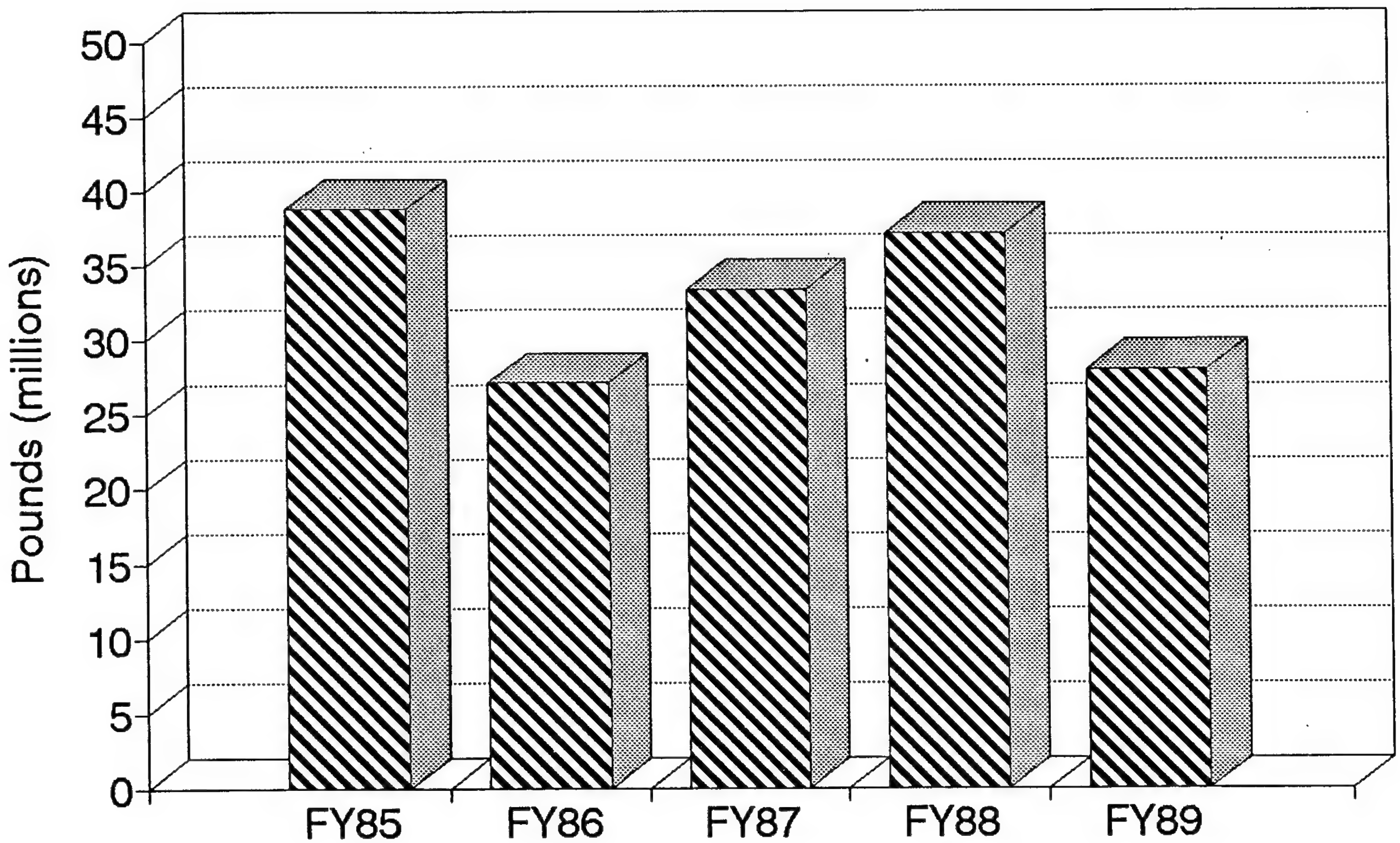


Figure 3-2

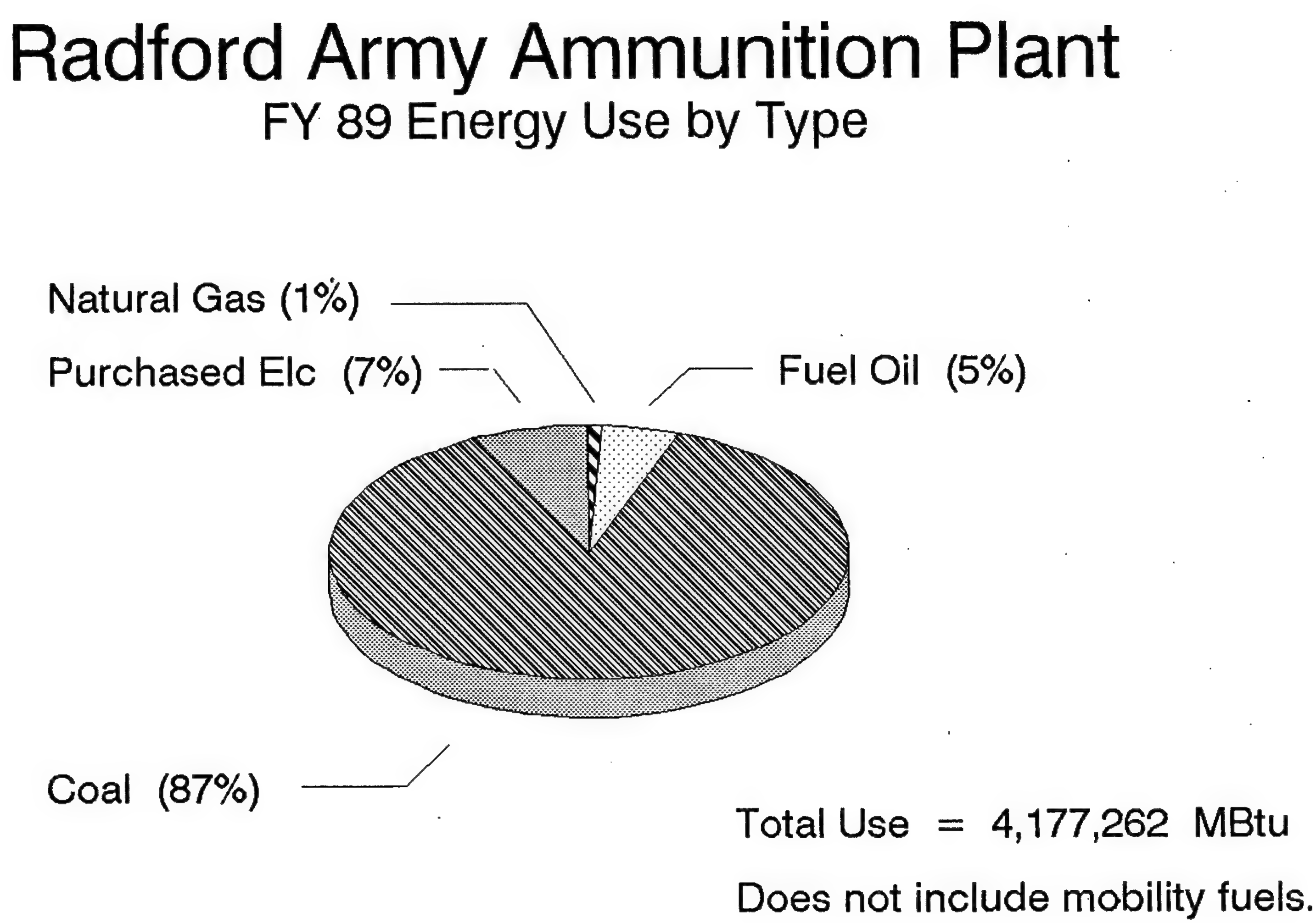

Radford Army Ammunition Plant
FY 89 Energy Use by Type
Natural Gas (1%)
Purchased Elc (7%)
Fuel Oil (5%)
Coal (87%)
Total Use = 4,177,262 MBtu
Does not include mobility fuels.

Figure 3-3

Radford Army Ammunition Plant

FY 89 Energy Cost by Type

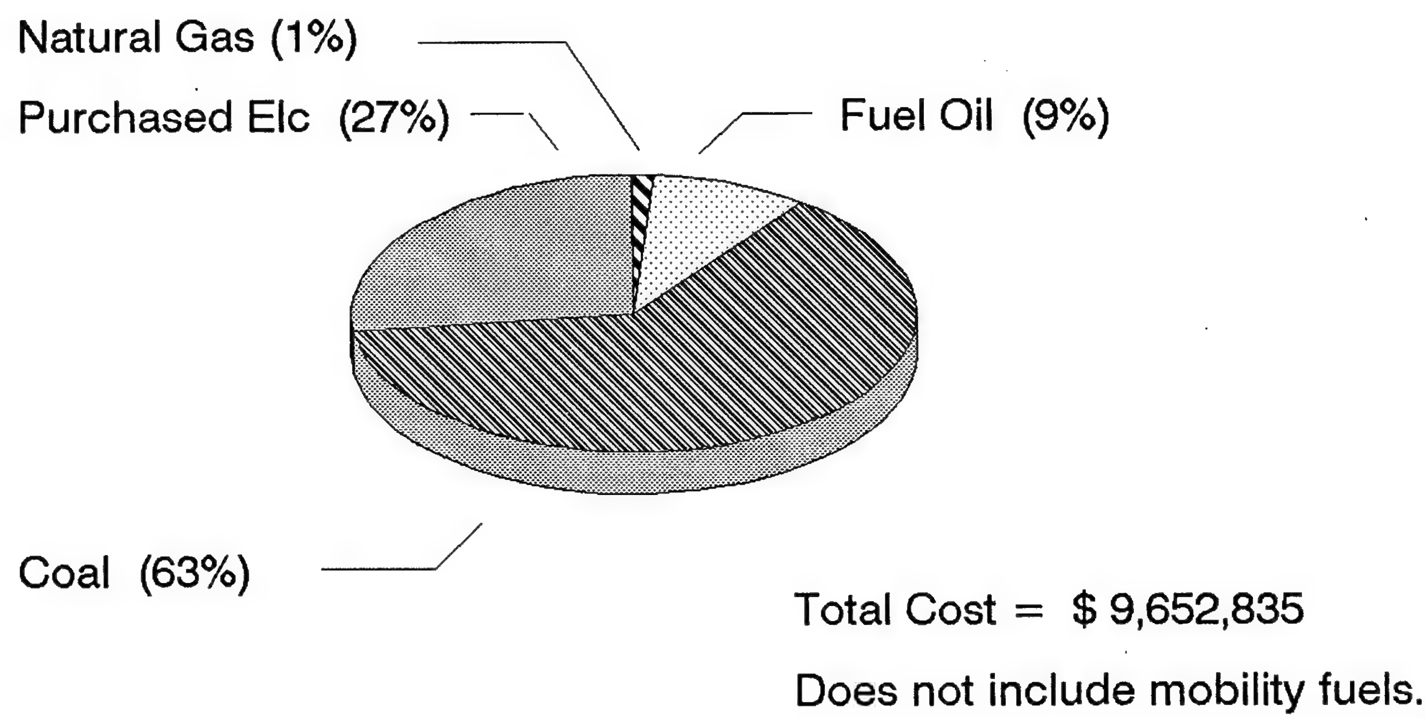


Figure 3-4

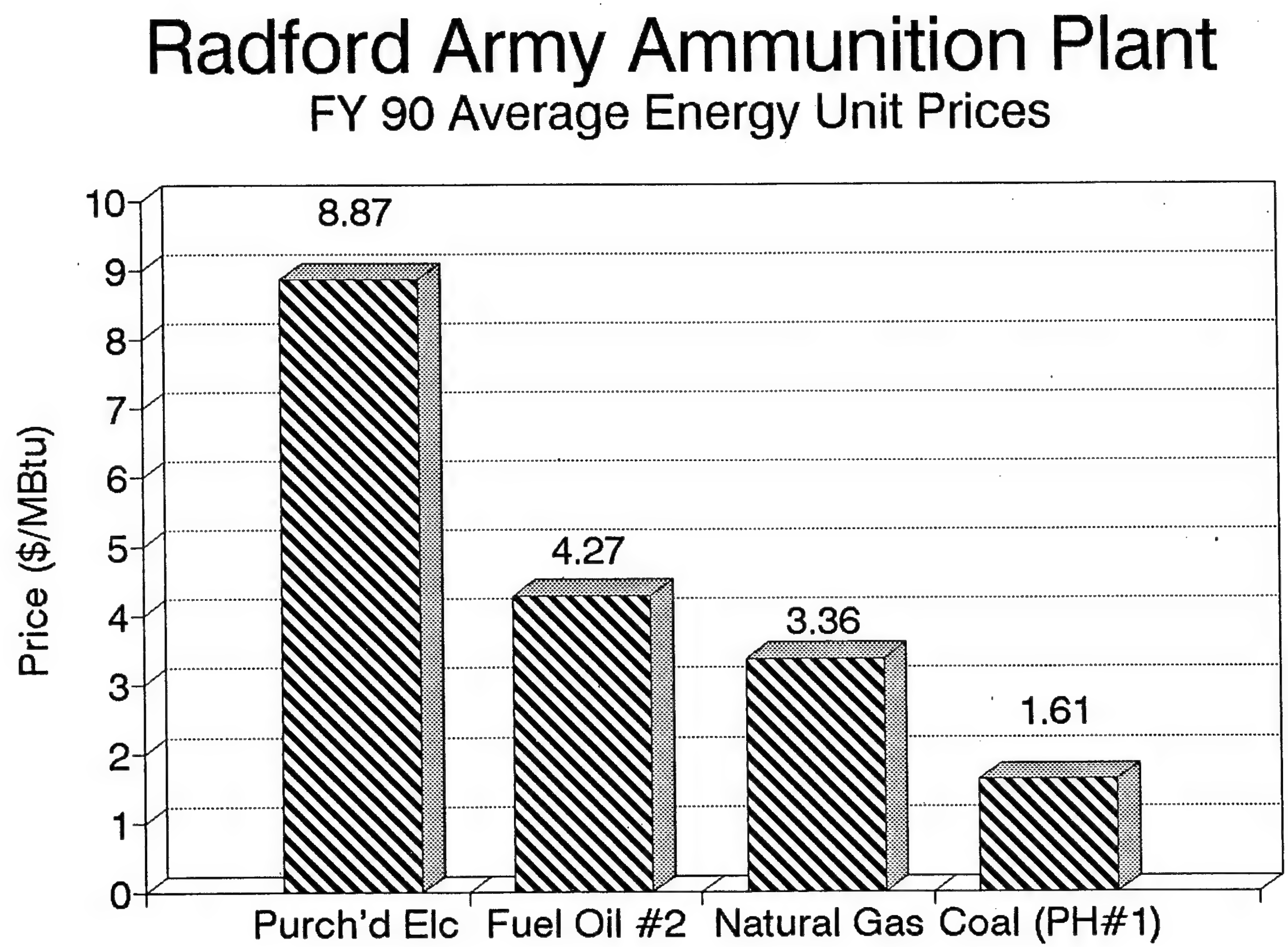

Radford Army Ammunition Plant
FY 90 Average Energy Unit Prices
Price ($/MBtu)
0
1
2
3
4
5
6
7
8
9
10
8.87
4.27
3.36
1.61
Purch'd Elc
Fuel Oil #2
Natural Gas
Coal (PH#1)

Figure 3-5

the six categories listed in Table 3-1. Plant utilities include Plant Water and Air and Cast Water and Air and the power houses. Steam consumption in Power House No. 1 is credited toward the generation of electricity (599,111 MBtu) based on power generation at 29 percent efficiency, and then allocated among the six categories. Table 3-1 shows the energy use breakdown by use and cost for FY 89.

The results show that about 87 percent of the energy on a Btu basis and 81 percent on a cost basis is directly used in production. The most energy intensive production areas are the acid and nitrocellulose areas.

3.2 Energy and Production Data Analysis

Historical energy consumption at Radford Army Ammunition Plant (RAAP) was analyzed using a linear regression analysis computer program to determine the dependency of primary energy use on variables that affect that use. In an industrial plant such as RAAP, these variables may be production end items, components of end-item production, number of employees, weather, or a combination of any of the above.

Analysis of RAAP energy data was done for the five fiscal years 1985 to 1989. Production for the five years of the four predominant quantities NC, AOP, NAC/SAC and NG is shown in Figure 3-6; percentages of the quantities for FY 89 are shown in Figure 3-7.

A linear regression analysis resulted in the following monthly five-year energy consumption equations:

Coal: $$\text{MBtu} = 95{,}000 + 220\ \text{HDD} + 0.061\ \text{NC} \quad (1)$$

$$R^2\text{adj} = 0.802$$

Elec: $$\text{MBtu} = 26{,}880 + 0.00171\ (\text{AOP} + \text{NAC/SAC}) \quad (2)$$

$$R^2\text{adj} = 0.603$$

TABLE 3-1. RADFORD AAP ENERGY USE - FY 89

	ENERGY USE		END USERS					
					PROCESS			
FUEL TYPE	MBTU	$	ADM & BLDG HEAT	PLANT UTILITIES	ACID & NC	SOLVENT	S'LESS	OTHER
COAL (1)			111,700	-	1,050,083	705,066	1,033,875	139,111
Steam	3,039,835	$5,076,525	$186,539	-	$1,753,639	$1,177,460	$1,726,572	$232,315
Electricity	599,111	$1,000,515						
			78,144	214,451	232,580	158,211	161,668	54,272
PURCHASED			$313,105	$859,251	$931,891	$633,913	$647,764	$217,456
ELECTRICITY	300,215	$2,602,864						
			1,719	119,617	-	-	-	81,144
FUEL OIL #2	202,480	$857,843	$7,283	$506,781	-	-	-	$343,780
			-	-	8,507	23,608	-	2,986
NATURAL GAS	35,101	$115,131	-	-	$27,904	$77,433	-	$9,794
			-	-	-	-	-	534
PPG	534	$3,000	-	-	-	-	-	$3,000
TOTALS	4,177,276		191,563	334,068	1,291,170	886,885	1,195,543	278,047
			4.6%	8.0%	30.9%	21.2%	28.6%	6.7%
TOTALS		$9,655,878	$506,927	$1,366,032	$2,713,434	$1,888,806	$2,374,336	$806,345
			5.2%	14.1%	28.1%	19.6%	24.6%	8.4%

(1) Total coal = 3,638,946 MBtu and $6,077,040

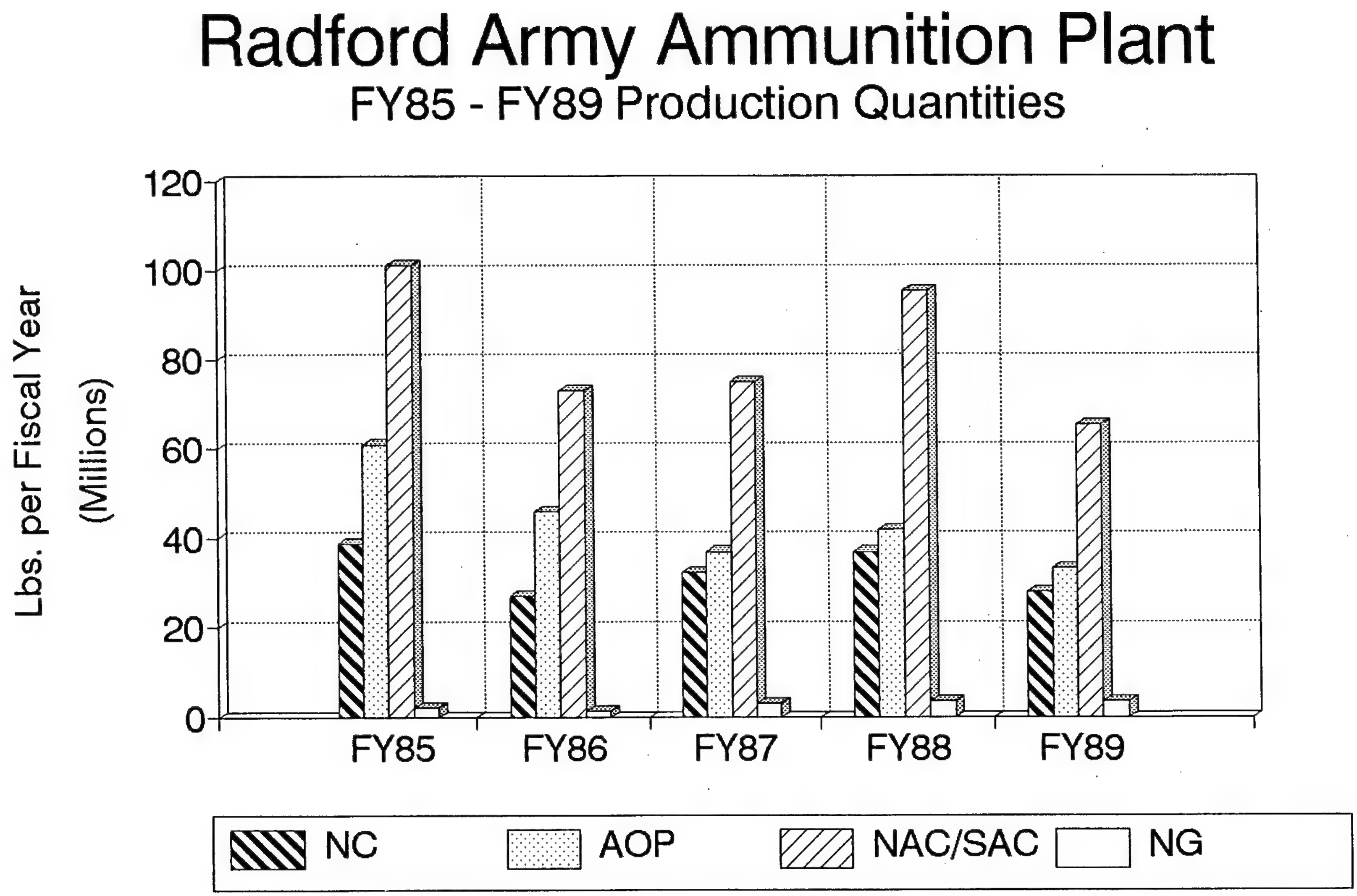

Radford Army Ammunition Plant
FY85 - FY89 Production Quantities
Lbs. per Fiscal Year
(Millions)
120
100
80
60
40
20
0
FY85
FY86
FY87
FY88
FY89
NC
AOP
NAC/SAC
NG

Figure 3-6

Radford Army Ammunition Plant

FY89 Production Quantities

Total = 129,941,696 lbs.

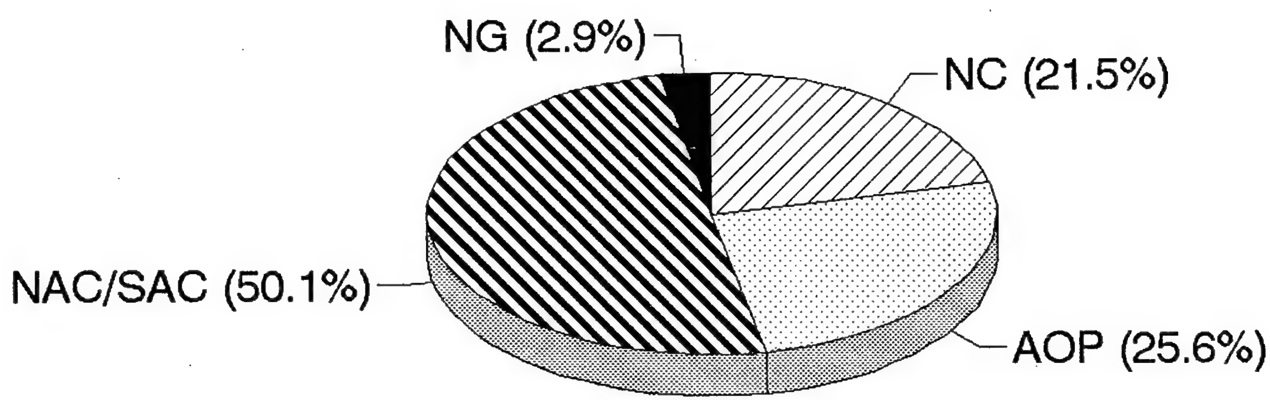


Figure 3-7

Where:

HDD	=	heating degree-days (base 65°F)
NC	=	nitrocellulose production (lbs)
AOP	=	ammonia oxidation production (lbs)
NAC/SAC	=	concentrated acid production (lbs)
R^2adj	=	R^2 adjusted for the number of variables and observations thereby providing an unbiased estimate

Figures 3-8 and 3-9 show the comparisons of the measured energy consumption to that calculated using the above equations.

The consumption of coal for the fiscal years 1985 to 1989 was most dependent on production, specifically that of NC. The total consumption of coal over the five-year period was approximately 21,172,000 MBtu; according to equation (1), approximately 5,505,000 MBtu, or 26 percent was due to weather; 9,955,300 MBtu, or 47 percent was related directly to production; and 5,711,700 MBtu, or 27 percent was not dependent on either (Figure 3-10).

The strongest correlation found for electricity was with the ammonia oxidation process (AOP) and the acid-concentration processes (Figure 3-9). There is no significant correlation of electricity use with weather.

Total electricity use at RAAP during the five-year period was 2,687,500 MBtu; equation (2) shows that 1,074,800 MBtu (40 percent) was related to AOP and NAC/SAC production, while 1,612,700 MBtu (60 percent) represents a yearly constant use (Figure 3-11).

When summarized, significant energy use at RAAP can be divided into three components, each of which offer opportunities for savings. The three components are:

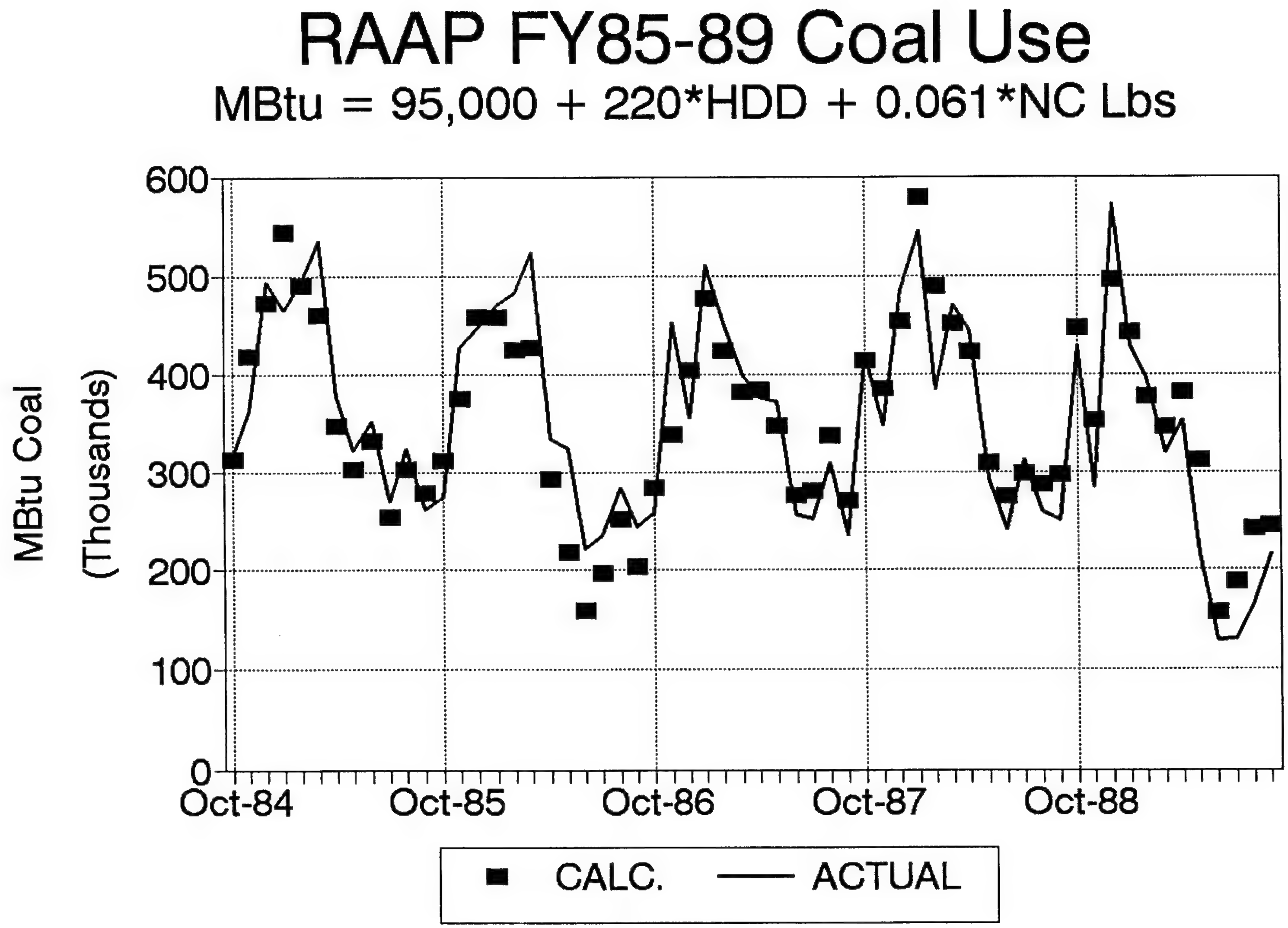

RAAP FY85-89 Coal Use
MBtu = 95,000 + 220*HDD + 0.061*NC Lbs
MBtu Coal
(Thousands)
600
500
400
300
200
100
0
Oct-84
Oct-85
Oct-86
Oct-87
Oct-88
CALC.
ACTUAL

Figure 3-8

RAAP FY85-89 Electricity Use

MBtu = 26800 + 0.00171*Lbs(AOP+NAC/SAC)

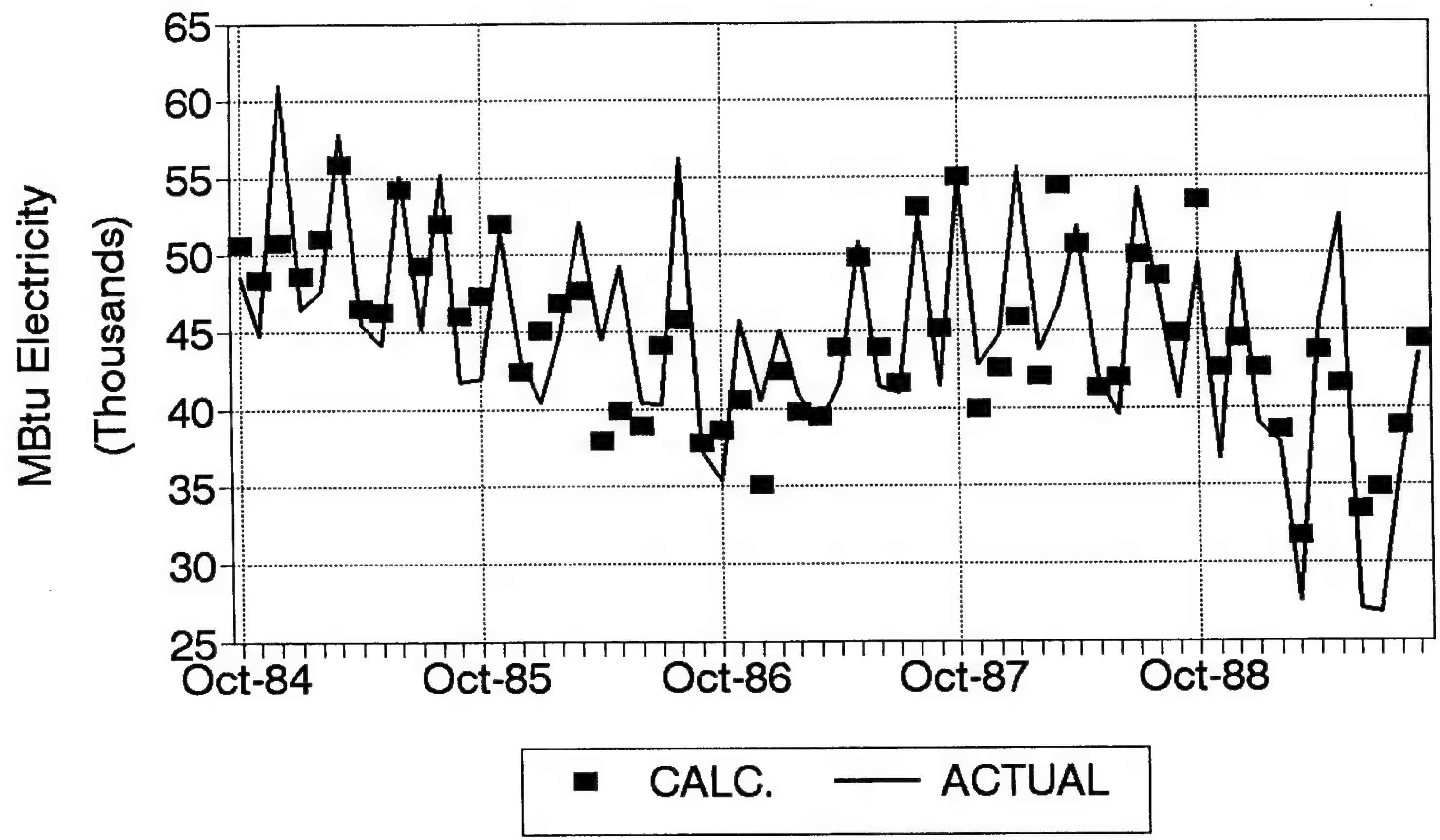


Figure 3-9

Radford Army Ammunition Plant
FY85-89 Coal Consumption Components

Total = 21,172,000 MBtu

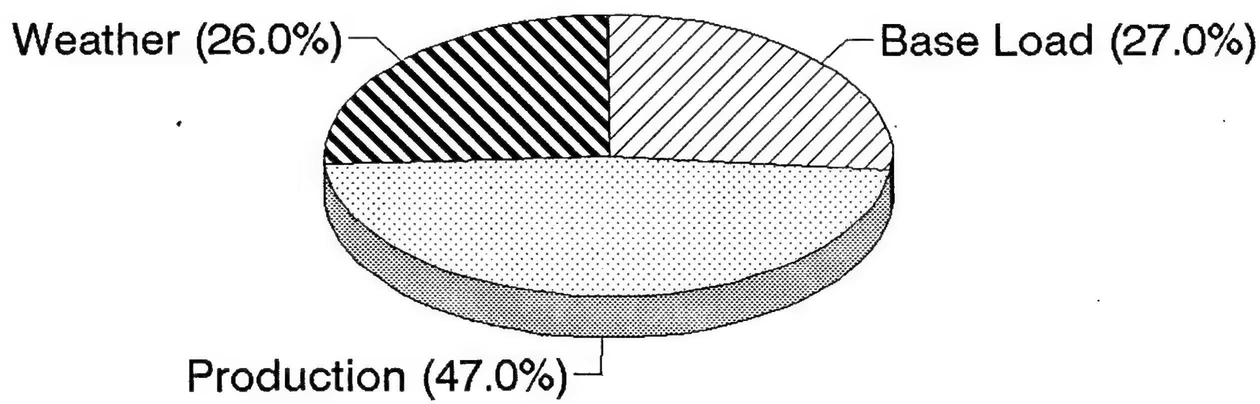


Figure 3-10

Radford Army Ammunition Plant

FY85-89 Elect. Consumption Components

Total = 2,687,500 MBtu

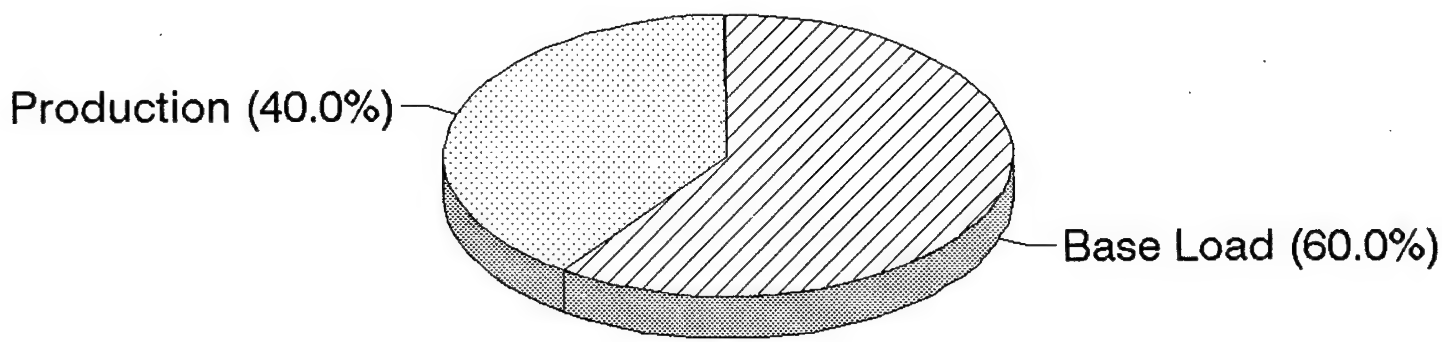


Figure 3-11

1. Production-related--over 40 percent of the variations in coal and electricity use at RAAP are directly related to changes in production. This is not a contradiction of the 86 percent process energy use fraction calculated in Section 2.3 using RAAP sub-metered data. Energy use was labelled process energy in Section 2.3 because it was used in production buildings. Therefore it included many uses that do not vary with production, such as, lighting and space heating.
2. Weather-related--over 26 percent of coal use is directly related to variances in cold weather. This is not surprising, since the use of building insulation is greatly restricted in an ammunition plant.
3. Constant energy use--the remainder of energy use, approximately 27 percent of coal and 60 percent of electricity, is more or less independent of any variations in weather or production. This represents such items as lighting and production standby heating and electrical requirements.

4.0 ENERGY CONSERVATION ANALYSIS

4.1 Energy Conservation Opportunity (ECO) Assessment

Each of the ECOs listed in the Scope of Work plus others were reviewed for their applicability and potential for significant energy savings and cost effectiveness for buildings representative of high energy consumption production areas at RAAP. The buildings actually surveyed vary from the list in the scope of work, but the intent of the survey was accomplished--to survey and investigate energy savings in the major energy users in all active production areas. The results of this assessment are contained in tables in Appendix B of Volume I.

For each of the ECOs that were chosen to be evaluated, energy savings were calculated, cost estimates made and life cycle cost analyses performed. A summary of the results are contained in Tables 4-1 and 4-2. The evaluated ECOs are described and listed alphabetically by process area in Table 4-1. Note that Net Cost Savings includes additional purchased electricity and all non-energy savings (costs). An alphabetical listing of evaluated ECOs along with a summary of the energy and cost savings analysis is shown in Table 4-2. Table 4-3 contains a listing prioritized by SIR. Table 4-4 contains a list prioritized by simple payback.

4.2 EEAP Study Update

An Energy Engineering Analysis Program (EEAP) was accomplished by Hayes, Seay, Mattern and Mattern and documented in a report dated January 1982. Three projects were recommended that are to be updated in this report:

- o T-102-G, Replacement and installation of gate valves
- o T-108, Change house modifications
- o WO-114G, Water dry tank covers

Table 4-1. ECOs Evaluated - Titles

#	ECO #	Description
1	FN-U-1	Cover water dry tank surface with insulating spheres
2	FN-U-2	Insulate fiberglass water dry tanks
3	GP-B-1	Install energy efficient motors
4	GP-B-2	Install energy efficient motors - upon failure
5	GP-B-3	Install energy efficient motors instead of rewind
6	GP-B-4	Install variable frequency drives on plant water pumps
7	GP-D-1	Replace existing IGG with heat recovery type
8	GP-D-2	Install condensing heat exchanger at Power House #1
9	GP-N-1	Replace incandescents with 35W HPS screw-ins
10	GP-N-2	Replace incandescents with Circline fluorescents
11	GP-N-3	Replace exterior incandescents with fluorescents
12	GP-N-4	Replace 40W fluorescents with 34W
13	GP-N-5	Replace lamps and ballasts with energy efficient types
14	GP-N-6	Replace incandescents with HPS fixtures
15	GP-N-7	Replace inefficient ballasts
16	GP-N-8	Replace incandescents with color-corrected HPS screw-ins
17	GP-N-9	Replace 40W fluorescents with 34W upon failure
18	GP-N-10	Replace inefficient ballasts upon failure
19	GP-W-1	Install vinyl strip door curtains
20	GP-X-1	Reduce exhaust gas temperature in incinerator
21	GP-X-2	Reduce water flow into incinerator
22	GP-X-3	Reduce incinerator excess air
23	GP-X-4	Install turning vanes in boiler ductwork
24	GP-X-5	Install thermostat control system in motor houses
25	GP-X-6	Change incinerator fuel to natural gas
26	MF-X-1	Install preheat coil controls in FADs
27	NC-U-1	Insulate boiling and poacher tubs
28	NC-X-1	Modify boiling tub heating method
29	SR-I-1	Remove steam coils in Activated Carbon Area

Table 4-2. ECO Evaluations - Results

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	FN-U-1	$52,643		0	12,258	0	0	$9,427	5.31	2.07
2	FN-U-2	$45,905		0	2,822	0	0	$2,170	20.12	0.75
3	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
4	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--
5	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--
6	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
7	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
8	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
10	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
11	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
12	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
13	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
14	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
15	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
16	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
17	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
18	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
19	GP-W-1	$19,251		0	16,055	0	0	$12,348	1.48	3.00
20	GP-X-1	***		0	0	18,308	0	$78,175	***	***
21	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
22	GP-X-3	***		0	0	18,572	0	$79,300	***	***
23	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
24	GP-X-5	$42,488		0	4,602	0	0	$3,540	11.42	1.33
25	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
26	MF-X-1	$64,219		0	706	0	0	$933	65.50	0.16
27	NC-U-1	$70,271		0	6,674	0	0	$5,133	13.02	0.84
28	NC-X-1	$122,374		0	123,431	0	0	$94,927	1.23	8.97
29	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 4-3. Results Of ECO Evaluations - Prioritized By SIR

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	GP-X-3	***		0	0	18,572	0	$79,300	***	***
2	GP-X-1	***		0	0	18,308	0	$78,175	***	***
3	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
4	NC-X-1	$122,374		0	123,431	0	0	$94,927	1.23	8.97
5	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20
6	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
7	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
8	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
10	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
11	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
12	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
13	GP-W-1	$19,251		0	16,055	0	0	$12,348	1.48	3.00
14	FN-U-1	$52,643		0	12,258	0	0	$9,427	5.31	2.07
15	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
16	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
17	GP-X-5	$42,488		0	4,602	0	0	$3,540	11.42	1.33
18	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
19	NC-U-1	$70,271		0	6,674	0	0	$5,133	13.02	0.84
20	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
21	FN-U-2	$45,905		0	2,822	0	0	$2,170	20.12	0.75
22	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
23	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
24	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
25	MF-X-1	$64,219		0	706	0	0	$933	65.50	0.16
26	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
27	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
28	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--
29	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 4-4. Results Of ECO Evaluations - Prioritized By Simple Payback

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	GP-X-3	***		0	0	18,572	0	$79,300	***	***
2	GP-X-1	***		0	0	18,308	0	$78,175	***	***
3	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
4	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20
5	NC-X-1	$122,374		0	123,431	0	0	$94,927	1.23	8.97
6	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
7	GP-W-1	$19,251		0	16,055	0	0	$12,348	1.48	3.00
8	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
10	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
11	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
12	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
13	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
14	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
15	FN-U-1	$52,643		0	12,258	0	0	$9,427	5.31	2.07
16	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
17	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
18	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
19	GP-X-5	$42,488		0	4,602	0	0	$3,540	11.42	1.33
20	NC-U-1	$70,271		0	6,674	0	0	$5,133	13.02	0.84
21	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
22	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
23	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
24	FN-U-2	$45,905		0	2,822	0	0	$2,170	20.12	0.75
25	MF-X-1	$64,219		0	706	0	0	$933	65.50	0.16
26	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
27	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
28	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--
29	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Replacement and Installation of Gate Valves

The project involves replacement of 137 gate valves and installation of one new valve in the "A" line powder area and four in the (Increment No. 1) first rolled powder area.

All known valves that were leaking have been either repaired or replaced by Hercules. Steam is now "valved off" to prevent flow to unneeded areas or buildings.

Change House Modifications

This project called for the installation of new fluorescent lighting to replace existing incandescent systems. This project has been accomplished.

Water Dry Tank Covers

Water dry tanks are open to the atmosphere, allowing heated water vapor and ether to escape during the drying cycles. This project would provide a fiberglass tank cover designed to collect the ether. Chilled water coils would condense the ether on the underside of the cover allowing the liquid ether to return to the tank.

This project has been rejected by RAAP engineering staff as not meeting existing safety requirements.

4.3 Operations and Maintenance Energy Savings

As a result of the site visits to Radford AAP, several operations and maintenance (O&M) energy savings ideas were identified. Energy and economic analyses were performed. The results of these analyses are presented below.

- Upon Failure, Rewind or Purchase a New Energy-Efficient Motor

The current practice is to rewind all motors unless the cost of the rewind is greater than 50 percent of the cost of a new motor. Analysis shows that this decision depends on the motor utilization. For one-shift operation, the cost of rewind would have to be greater than 75 percent of the cost of a new energy-efficient motor. For a two-shift operation, the 50-percent value is reasonable. For three-shift operation, it is economical to purchase new motors if the cost of rewind exceeds 25 percent for motors less than 200 horsepower.

- Upon Failure, Replace Standard Fluorescent Lamps with Energy-Efficient Types

Current practice is to replace failed fluorescent lamps with standard 40 W lamps. Replacing failed lamps with 34 W lamps saves about $1.13 per year for each lamp based on 6,240 hour/year operation. The incremental cost is the difference between the cost of the two lamps, which is $0.75 per lamp. This yields a payback of about 8-1/2 months.

- Upon Failure, Replace Standard Fluorescent Fixture Ballasts with Energy-Efficient Types

Currently, fluorescent fixtures use standard ballasts. By replacing these ballasts with energy efficient types when they fail, installation charges are avoided and a 20-percent reduction in energy use is accomplished.

Estimated savings are about 13 watts per two-lamp fixture or $2.45 per fixture per year based on 6,240 hour/year operation. The cost is the difference between energy-efficient and standard ballasts, which is about $6.67 per ballast. This yields a simple payback of 2.7 years.

- Upon Failure, Replace Standard Electric Motors with Energy-Efficient Types

  The current policy is to replace a failed motor that cannot be economically repaired with a standard type. Energy-efficient motors offer efficiency improvements of three to nine percent and carry a cost premium of 50 to 60 percent over standard motors. The cost-effectiveness of this policy depends on the utilization of the motor. The results indicate that energy-efficient types should be purchased for all motors operating greater than one shift per day.

- Reduce the Exit Gas Temperatures on the Waste Propellant Incinerators

  Waste propellant is carried to the incinerators mixed with water. Fuel oil is burned to evaporate this water and incinerate the waste propellant. The existing practice is to operate the incinerator at an exit gas temperature of about 1400°F. This temperature can be lowered by reducing the fuel oil flow to the burners. If the exit gas temperature is reduced to 500°F, the annual energy savings are $78,000. The existing permits may not allow this temperature reduction, but at $78,000 per year, it is worthwhile to pursue modifying the permit.

- Reduce the Amount of Oxygen in the Waste Propellant Incinerator Exit Gas

  The waste propellant incinerator currently operates with an exit gas oxygen level of 15 percent. Efficient operation of #2 fuel oil combustion

equipment requires about three percent oxygen. Reducing this level by a simple adjustment of the combustion controls will save about $80,000 per year.

- Power House #1 Operation

Power House #1 generates both steam and electricity for Radford AAP. It is the current practice to generate steam required to meet the plant demands. The resulting power generated by supplying steam turbines 400 psia steam is also utilized by the plant. The balance is purchased from the utility.

There are two types of turbines, backpressure (non-condensing) and condensing. The amount of steam sent to the condensing stage is minimized, since this is the least efficient stage of the turbine. Also, excess condensing during low power demand periods could cause Radford AAP purchases to fall below its contracted minimum of 7,800 kW.

However, an analysis of the turbine/generator performance curves supplied by Radford shows that if the flow to the condensing section is small enough, the efficiency of that stage drops rapidly. The shape of this curve indicates that flow to the condensing section should never drop below 15,000 pounds per hour and should probably remain around 20,000 pounds per hour. Operating at 10,000 pounds per flow to the condenser could cost up to $110,000 annually.

4.4 Low Cost/No Cost Projects

During the site survey, several low cost/no cost energy conservation opportunities were found. These were grouped by project type and evaluated for cost effectiveness. Each is analyzed separately and the results are contained in Table 4-5.

There are five basic project types:

LCNC 1: Repair Steam Leaks

LCNC 2: Turn Off Unneeded Lights

LCNC 3: Repair Steam Pipe Insulation

LCNC 4: Turn Off Steam When Not Needed

LCNC 5: Repair Leaking Compressed Air Valve

Table 4-5. Low Cost/No Cost Projects

Number	Cost	Energy Savings (MBtu/year) Coal	Electric	Energy Cost Savings
LCNC-1	$9,642	$7,260	--	$5,584
LCNC-2	--	--	150	1,325
LCNC-3	1,657	342	--	263
LCNC-4	--	384	--	296
LCNC-5	86	--	84	742
TOTALS	$11,385	$7,986	$234	$8,210

LCNC-1 = Repair steam leaks
LCNC-2 = Turn of unneeded lights
LCNC-3 = Repair steam pip insulation
LCNC-4 = Turn off steam when no needed
LCNC-5 = Repair leaking compressed air valve

5.0 ENERGY PLAN

5.1 Project Packaging

The ECOs listed in Table 4-2 were evaluated for appropriate funding category. The project scope of work listed the following guidelines on this subject.

	Project Cost	Simple Payback
QRIP	< \$100,000	≤ 2 yrs.
OSD PIF	> \$100,000	≤ 4 yrs.
PECIP	> \$ 3,000	≤ 4 yrs.
ECAM	---	≤ 10 yrs., SIR > 1.0

AMCCOM provided the following changes for AMC installations in general and to be used for Radford AAP.

	Project Cost	Simple Payback
QRIP	\$5,000-\$100,000	≤ 2 yrs.
OSD PIF	> \$100,000	≤ 4 yrs.
PECIP	> \$100,000	≤ 4 yrs.
ECAM	---	≤ 10 yrs., SIR > 1.0

Form 1391 is required only for those ECAM projects costing greater than \$200,000.

Table 5-1 contains the results of the analysis with the project funding category listed in the far right column. Projects GP-W-1 and NC-U-1 were not recommended because of safety concerns of RAAP Safety Division. Table 5-2 lists the ECOs by project funding category.

Based on guidance from Hercules Project Administration, the QRIP and OSD PIF forms were completed and are found in Volume IV. Those ECOs qualifying for ECAM funding are submitted by RAAP on an annual basis under the program named Production Support and Equipment Replacement. For ECAM projects, Radford requested that only the project discussion, economic analysis and calculations backup be provided.

Table 5-1. Results Of ECO Evaluations - Project Funding

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR	Project Funding
1	GP-X-3	***		0	0	18,572	0	$79,300	***	***	-
2	GP-X-1	***		0	0	18,308	0	$78,175	***	***	-
3	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36	QRIP
4	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20	QRIP
5	NC-X-1	$122,374		0	123,431	0	0	$94,927	1.23	8.97	QRIP
6	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52	QRIP
7	GP-W-1	$19,251		0	16,055	0	0	$12,348	1.48	3.00	NR
8	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83	QRIP
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67	OSD PIF
10	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59	OSD PIF
11	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38	ECAM
12	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80	OSD PIF
13	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13	NR
14	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87	ECAM
15	FN-U-1	$52,643		0	12,258	0	0	$9,427	5.31	2.07	ECAM
16	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45	NR
17	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35	NR
18	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01	NR
19	GP-X-5	$42,488		0	4,602	0	0	$3,540	11.42	1.33	NR
20	NC-U-1	$70,271		0	6,674	0	0	$5,133	13.02	0.84	NR
21	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78	NR
22	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70	NR
23	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69	NR
24	FN-U-2	$45,905		0	2,822	0	0	$2,170	20.12	0.75	NR
25	MF-X-1	$64,219		0	706	0	0	$933	65.50	0.16	NR
26	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--	-
27	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--	-
28	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--	-
29	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--	-

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 5-2. Project Funding List

QRIP

- GP-X-2 - Reduce Water Flow to Incinerator (one unit only)
- SR-I-1 - Remove Steam Coils in Activated Carbon Area
- GP-N-3 - Replace Exterior Incandescents with Fluorescents
- GP-X-4 - Install Turning Vanes in Boiler Ductwork
- NC-X-1 - Modify Boiling Tub Heating Method (one tub only)

OSD PIF

- GP-B-4 - Install Variable Frequency Drives
- GP-N-1 - Replace Incandescents with 35W HPS Screw-Ins
- GP-X-6 - Change Incinerator Fuel to Natural Gas

ECAM

- FN-U-1 - Cover Water Dry Tanks with Insulating Spheres (one tank only)
- GP-N-8 - Replace Incandescents with Color-Corrected HPS Screw-Ins
- GP-N-2 - Replace Incandescents with Circline Fluorescents

5.2 Energy and Cost Savings

Energy and cost savings for the recommended project funding are listed in Table 5-3. The implementation of all projects yield a total annual energy savings of 160,023 MBtu and annual cost savings equal to $420,633. Low cost/ no cost adjustments in the waste propellant incinerator (projects GP-X-1 and GP-X-3 in Table 4-4) yield another 36,880 MBtu and $157,475 annual energy and cost savings, respectively. This totals to 196,903 MBtu and $578,108 annual savings, which represents reductions of 4.7 percent and 6.0 percent, respectively. Figures 5-1 and 5-2 show energy use and cost, respectively, at Radford AAP before and after implementation of these projects.

5.3 Project Schedule

Hercules Project Administration provided the following project implementation dates:

QRIP, OSD PIF and PECIP	FY92 (at earliest)
ECAM	FY95

Following this schedule, Figure 5-3 was developed to show the impact implementation the recommended projects would have on energy use at RAAP. QRIPs for one unit only would be implemented in FY92 with the remainder in FY95.

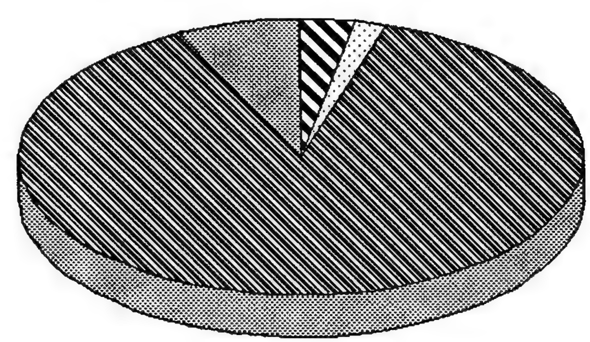
Table 5-3. Project Energy and Cost Savings

#	ECO #	Construction Cost Plus SIOH	Savings (Increase), MBtu/Year				Net Cost Savings	Simple Payback	SIR	Project Funding	PROGRAM YEAR (FY)	ESC'D COST
			Elec	Coal	Dist	N Gas						
1	NC-X-1a	$9,413	0	11,221	0	0	$8,630	1.23	8.97	QRIP (1)	92	$10,692
2	GP-X-2a	$7,415	0	0	1,971	0	$8,416	0.84	20.36	QRIP (1)	92	$8,422
3	SR-I-1	$17,932	1,576	0	0	0	$13,979	1.22	7.20	QRIP	92	$20,367
4	GP-N-3	$22,667	1,024	0	0	0	$15,770	1.37	6.52	QRIP	92	$25,745
5	GP-X-4	$40,512	2,480	0	0	0	$21,998	1.67	6.83	QRIP	92	$46,014
6	GP-N-1	$132,467	4,003	0	0	0	$65,833	1.91	4.67	OSD PIF	92	$150,456
7	GP-B-4	$195,266	10,940	0	0	0	$96,994	1.91	4.59	OSD PIF	92	$221,783
8	GP-X-6	$263,750	0	0	86,217	(86,217)	$78,457	3.20	4.80	OSD PIF	92	$299,567
9	GP-N-2	$13,766	371	0	0	0	$6,416	2.04	4.38	ECAM	95	$17,191
10	FN-U-1a	$3,290	0	766	0	0	$589	5.31	2.07	ECAM (1)	95	$4,109
11	GP-N-8	$155,150	2,354	0	0	0	$31,081	4.80	1.87	ECAM (3)	95	$193,752
12	NC-X-1b	$112,960	0	112,210	0	0	$86,300	1.23	8.97	QRIP (2)	95	$141,065
13	GP-X-2b	$7,415	0	0	1,971	0	$8,416	0.84	20.36	QRIP (2)	95	$9,260
14	FN-U-1b	$49,353	0	11,490	0	0	$8,835	5.31	2.07	OSD PIF (2)	95	$61,632
	TOTALS	$1,031,356	22,748	135,687	90,159	(86,217)	$420,633	--	--	-	-	$1,016,303

1 Partial funding (for one unit only).
2 Funding for remaining units.
3 Alternate for GP-N-1. Costs and savings are not included in totals.

Radford Army Ammunition Plant

After Project Implementation



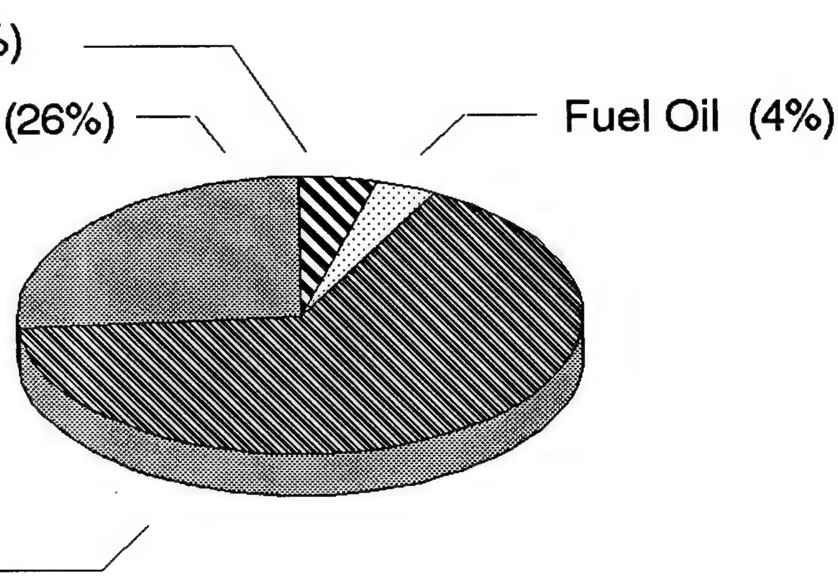
Total Use = 3,980,373 MBtu

Does not include mobility fuels.

Figure 5-1

Radford Army Ammunition Plant

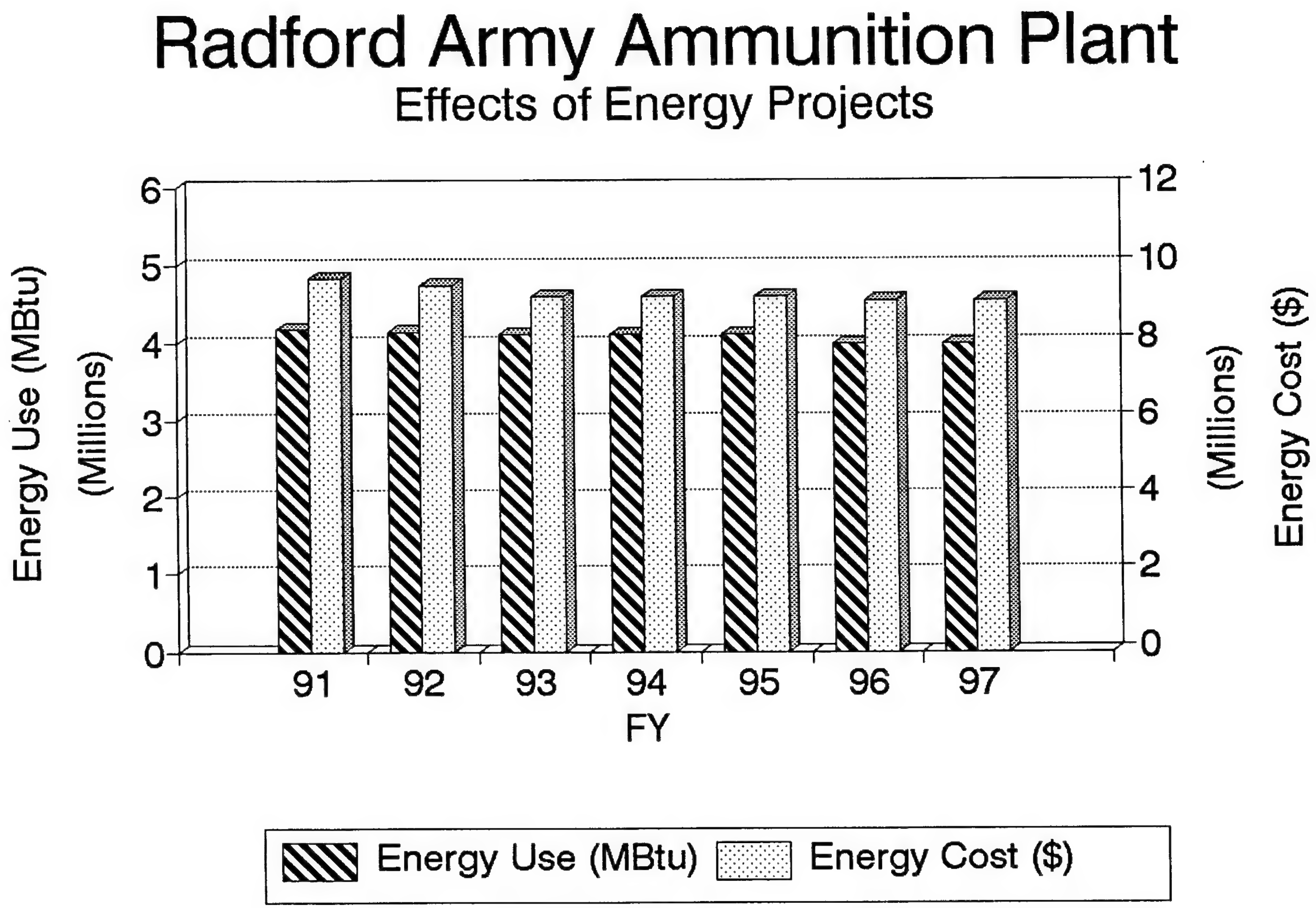
After Project Implementation



Total Cost = $ 9,077,770

Does not include mobility fuels.

Figure 5-2



Radford Army Ammunition Plant
Effects of Energy Projects
Energy Use (MBtu)
(Millions)
6
5
4
3
2
1
0
12
10
8
6
4
2
0
(Millions)
Energy Cost ($)
91
92
93
94
95
96
97
FY
Energy Use (MBtu)
Energy Cost ($)

Figure 5-3

1.0 INTRODUCTION

1.1 Purpose

In October 1989, the Corps of Engineers, Norfolk District, issued Contract No. DACA65-89-C-0154 with Hunter Services, Inc. of Jacksonville, Florida. This contract called for the performance of Energy Engineering Analysis Program (EEAP) studies of Army Industrial Facilities at Radford Army Ammunition Plant (RAAP), Radford, Virginia. The objective of this study is to identify, evaluate and develop energy saving projects which meet the criteria of the army's many energy funding programs.

1.2 Report Organization

The report consists of an Executive Summary and four volumes. Volume I, the Narrative Report, contains the results of all of the site surveys, analysis and project development. All backup data and calculations are found in Volume II. The site survey notes are in Volume III, and project documentation forms necessary for receiving funding are in Volume IV.

Volume I is the Narrative Report and its organization is explained here. Following a brief introduction in Section 1.0, the existing conditions at RAAP are discussed in Section 2.0. This includes a description of the installation, current and past energy use patterns and a regression analysis determining the impact of weather and production on installation energy use. Section 3.0 describes the techniques used to perform this study. Section 4.0 contains the results of the analysis of the energy conserving opportunities (ECOs) original EEAP study update and operation and maintenance savings. The ECO Implementation Plan and the effects on energy use at RAAP are located in Section 5.0.

2.0 EXISTING CONDITIONS

2.1 Installation Description

Radford Army Ammunition Plant is located just north of I-81, 47 miles southwest of Roanoke and 108 miles northeast of Bristol, Tennessee. The facility was built in 1941 and was the first to produce gun powder in the U.S. Government's defense plant program. This was the first creation of the GOCO (government-owned, contractor-operated) plant, dedicated wholly to the production of war material. Since 1941, RAAP has produced over two billion pounds of military propellants in such areas as:

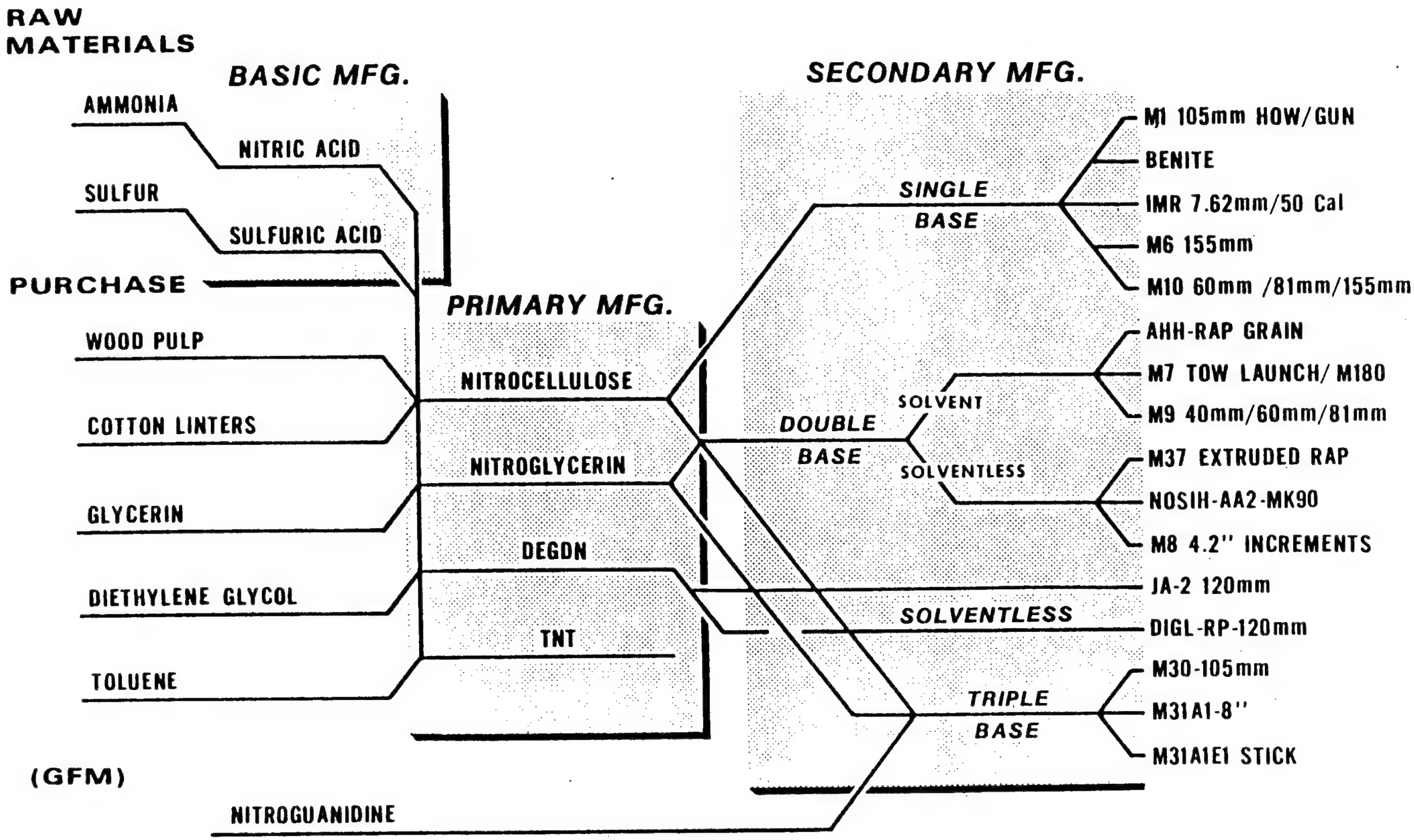
- Rockets
- Single-Base Propellants
- Solventless Propellants
- Double-Base Propellants
- Triple-Base Propellants
- Ignitors
- TNT
- Mortar Increments

Figure 2-1 contains a base materials flow diagram.

The RAAP installation includes approximately 7,000 acres and over 1,200 buildings. The employment level as in September 1989 was 5,350. Figure 2-2 is a site plan of RAAP and describes the basic production areas. Areas covered under this scope of work are:

Acid	Cast Propellant
Nitrocellulose B & C	Extruded Propellant
Solvent Recovery	Multibase Finishing
Finishing	Plant Air
Solventless	Plant Water

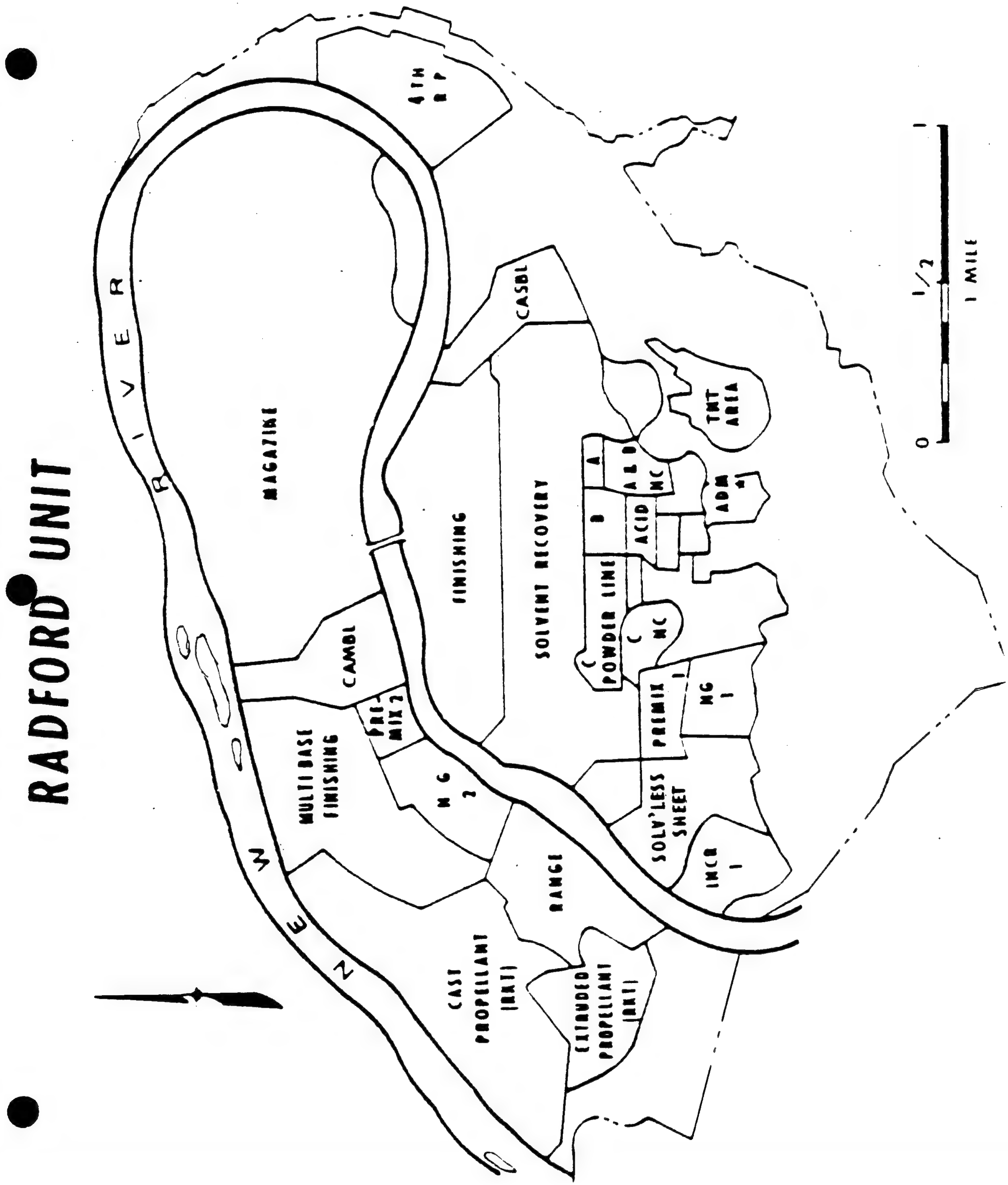
BASE MATERIALS FLOW DIAGRAM
FOR PROPELLANTS MANUFACTURED AT RAAP



ONLY A SAMPLE OF PROPELLANTS SHOWN

FIGURE 2-1

FIGURE 2-2


RADFORD UNIT
NEW RIVER
MAGAZINE
4TH RP
CASBL
FINISHING
SOLVENT RECOVERY
TNT AREA
A
A & B NC
B
ACID
ADM
POWDER LINE
C
C NC
PREMIX
1
NG 1
CAMBL
PRE-MIX 2
MULTI BASE FINISHING
NG 2
RANGE
SOLV'LESS SHEET
INCR 1
CAST PROPELLANT (RKT)
EXTRUDED PROPELLANT (RKT)
0
1/2
1 MILE

Increment 1

Nitroglycerin 1 & 2

Premix 1 & 2

4th Rolled Powder

Powerhouses 1 & 2

Inert Gas

Incinerators

Green Lines Solvent Propellant

Areas not included in the scope of work are:

Magazine

CAMBL

CASBL

TNT

Administration

Nitrocellulose A

2.2 Process Descriptions

2.2.1 Acid

2.2.2 Finishing

2.2.3 General Plan

2.2.3.1 Powerhouses

2.2.3.2 Incinerator

2.2.3.3 Inert Gas System

2.2.3.4 Plant Water

2.2.3.5 Wastewater Treatment

2.2.3.6 Compressed Air

2.2.4 Forced Air Dry

2.2.5 Nitrocellulose

2.2.6 Green Line Solvent Propellant

2.2.7 Nitroglycerin

2.2.8 Rocket

2.2.9 Rolled Powder

2.2.10 Solvent Recovery

2.2.1 Acid Area

Anhydrous ammonia is received via railcar at RAAP and stored in tanks in an area called #701. Low pressure steam is used to keep the ammonia warm (Figure 2-3).

The ammonia is heated to 165°F in the oxidation house (Building #702). Here it is mixed with 120 psia compressed air, heated to 266°F and ignited on a platinum catalyst. This reaction forms NO_x at 910°F. The gas is cooled to 80°F, and absorbed in water to form a weak (61 percent) nitric acid.

The weak nitric acid is pumped to the NAC/SAC (nitric acid concentrator/sulfuric acid concentrator) in Building #735-2. Here, sulfuric acid is used to dehydrate the nitric acid. This together with other steam consuming processes combine to make strong (98+ percent) nitric acid. The strong nitric acid is pumped to storage vessels, then pumped to weighing tanks prior to being pumped to the nitration building to begin the process of making nitrocellulose.

Due to the strict production requirements of energy savings potential here is minimal.

RAAP Process Flow Diagram

ACID AREA

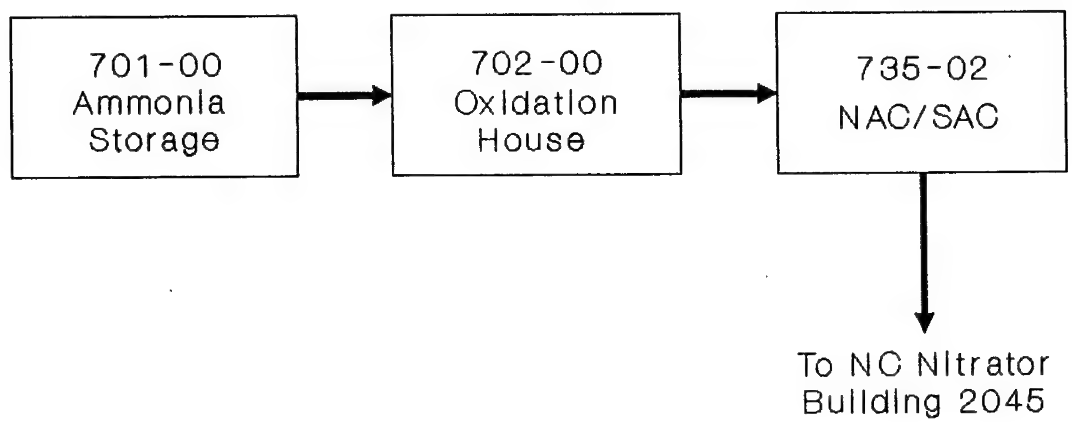


Figure 2-3

2.2.2 Finishing

Following the solvent recovery process, the propellant is transported to the finishing area. The finishing area includes the water dry, air dry, graphite glazing and packout operations.

2.2.2.1 Water Dry

The water dry process is used to remove residual ether and alcohol left in the propellant after the solvent recovery process. Open tanks are loaded with approximately 45,000-50,000 pounds of propellant depending upon the type of propellant being loaded, and then filled with filtered water. The water is circulated through steam heat exchanger until the temperature reaches 149°F. Depending on the type of propellant, the water dry process times range from four days to 20 days. The propellant is then removed and transported to the air dry buildings.

There are 32 water dry buildings at RAAP and 15 of them are currently active. There are two water dry tanks and one water tank in each building. The water dry tanks are about nine feet high and have a diameter of 16 feet. The original water dry tanks were made from banded redwood. These are gradually being replaced with fiberglass tanks. Currently, seven of the 15 active water dry buildings have the fiberglass water dry tanks.

2.2.2.2 Air Dry

The air dry process removes the moisture left on the propellant from water dry operation. Open air dry tanks are loaded with about 5,000 pounds of "wet" propellant. Outside air is heated to 145°F by steam heating coils and is blown into the bottom of the tank. The warm air absorbs moisture as it passes across the propellant and is then discharged to the atmosphere. Depending on the type of propellant the air dry process times range from five hours to 23 hours. The propellant is then removed and transported to a rest house or to the graphite glazing process.

There are ten air dry buildings at RAAP. Four of these buildings have five air dry tanks each and the remaining six buildings have two air dry tanks per building. Currently, three of the two-tank buildings are in the stand-by mode. The air dry tanks are made of steel or copper and are insulated.

2.2.2.3 <u>Graphite Glazing</u>

For propellants that require graphite glazing, which is one of the finishing processes, graphite is mechanically deposited on the propellant surface by using a motor-driven tumbler. The propellant is removed from the tumbler by rotating the barrel such that the inlet/outlet valve is positioned on the bottom of the tumbler. The valve is opened (by negative pressure) allowing the contents of the tumbler to flow by gravity. Also, a vacuum system is used to remove dust from the discharged material. The dust goes through a wet scrubber equipped with an induced draft fan. When this operation is completed, the propellant will either be packed into sublots for storage or transported to a screening operation.

2.2.3 General Plant

2.2.3.1 Power Houses

The No. 1 Power House (PH-1), Building #400, is dedicated solely to the production of steam for the Main Plant area and for production of electrical power for use throughout RAAP. The steam is used for process as well as comfort heating. Electricity is used for lighting, air-conditioning and process motors. Upon successful completion of the Steam Tie-Line Project, PH-1 will supply steam to the entire plant.

Steam is generated at 400 psig and 750°F from five pulverized coal-fired, balanced draft boilers rated at 175,000 lb/hr each. All five boilers discharge into a common steam header. From the common header the steam is expanded through either turbine generators (T/Gs) or pressure reducing valves (PRVs). The T/Gs can operate at maximum electrical production of 24 MW while consuming no less than 374,000 lb/hr and no greater than 538,000 lb/hr. With a boiler capacity of 175,000 lb/hr each, a minimum of three and a maximum of four boilers are necessary for full electrical production (Figure 2-4); however, full electrical power production is not a prime goal of the power house and has never been approached.

The power house is undergoing revision with the installation of new turbine generators according to the following schedule.

Date	Turbine Type
3/91	Condensing
6/91	Condensing
9/91	Backpressure
12/91	Backpressure

The horseshoe area currently receives steam from No. 2 Power House. In the very near future, Power House No. 2 is planned to be shut down. The

RAAP Process Steam Generation
After PH1 Modification

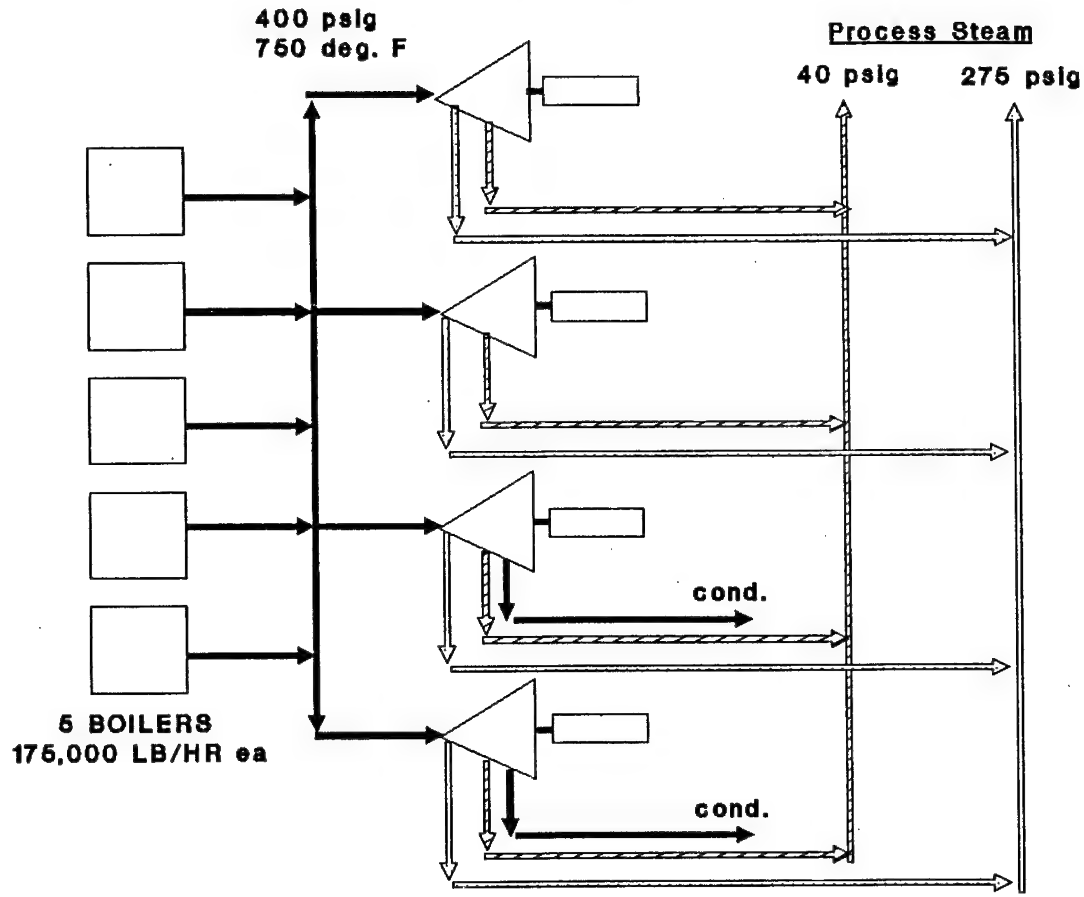


Figure 2-4

horseshoe area steam needs will be supplied from Power House No. 1 via a new tie line. Power House No. 1 will therefore be the sole source of steam for the facility and will be configured like Figure 2-4 once the new turbines are installed.

2.2.3.2 Incinerator

Explosive waste materials are dangerous and must be disposed of safely in an environmentally acceptable manner. Two incinerators exist for this purpose. The incinerators are No. 2 oil-fired rotary kiln-type with a wet marble bed scrubber for particulate matter emission control (Figure 2-5).

Explosive waste is reduced in size by wet grinding prior to being pumped to the incinerators. Explosive waste is then mixed with water to make it safe to handle in the vicinity of the hot incinerator. Each incinerator burns approximately 70 gallons/hr of No. 2 fuel oil to vaporize the water and ignite the waste materials that are fed to the incinerator burner at the rate of about 3.9 gpm.

Incinerator tests reveal the stack dry O_2 concentration is 15 percent. This is quite high and can be reduced. The kiln exit gas temperature is controlled at approximately 1,400^{0}F. This is also high and can be reduced.

The vast majority of the energy input to the incinerators is consumed in vaporizing the slurry transport water. Substantial money and energy can be saved if an acceptable method for reducing the amount of water entering the incinerator can be determined. Hercules' Safety Department has expressed concern regarding possible flame propagation if the water content of the slurry mixture is reduced at or near the burner.

RAAP Process Flow Diagram

Incinerator

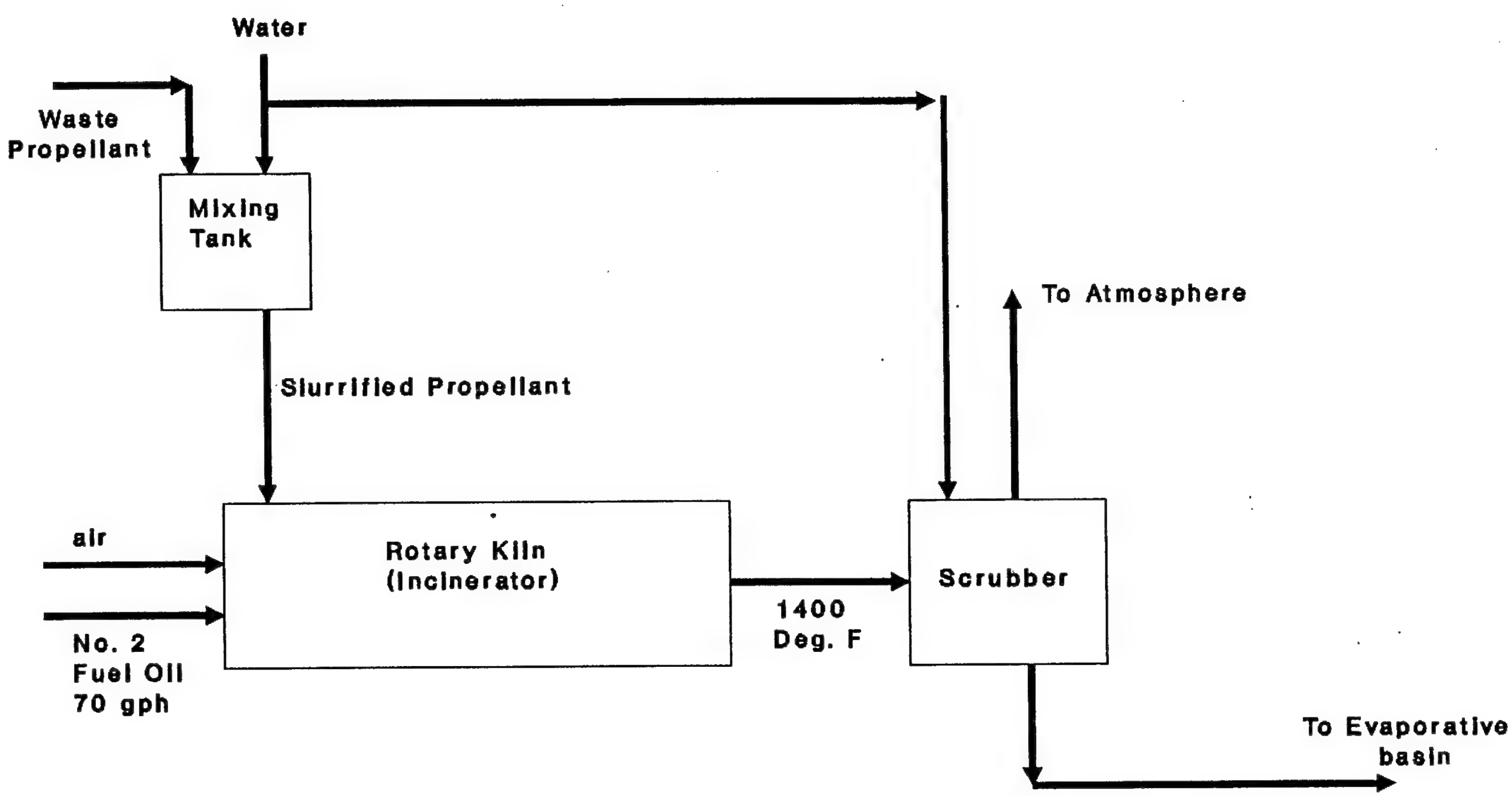


Figure 2-5

2.2.3.3 Inert Gas System

The inert gas generators produce a mixture of nitrogen and carbon dioxide for use as an inert drying medium to cure propellent and remove solvents. The inert gas is the clean dry product of combustion of natural gas in air.

Air and natural gas are first mixed in stoichiometric amounts and then burned. The products of combustion are heat, CO_2, CO, N_2 and H_2O. The heat is deliberately thrown away. The gaseous products are temporarily stored in a pillow (expansion) tank which serves as a reservoir for the compressors.

The compressors raise the gas pressure to 300 psig and directs it to carbon filters where carbon monoxide, water and oil from compression are removed. The inert gas is then directed to a series of storage tanks prior to being used for drying.

The heat of combustion is removed by a closed, water-cooled heat exchanger that is an integral part of the inert gas generator. The temperature rise of the water is held to a minimum by manually adjusting the flow to the maximum. The water passes through the heat exchanger once and is discharged to the sanitary sewer. The compressor cooling water is similarly discharged (Figure 2-6).

System energies that are currently wasted are:

- Heat of combustion
- Heat of compression
- Pumping energy from excessive water use
- Treatment energy from excessive water discharge

A request for funding has been made to replace the existing Inert Gas Plant System with a Pressure Swing Absorption (PSA) type nitrogen delivery system. The proposed system would provide nitrogen with higher purity and

RAAP Process Flow Diagram
Inert Gas System

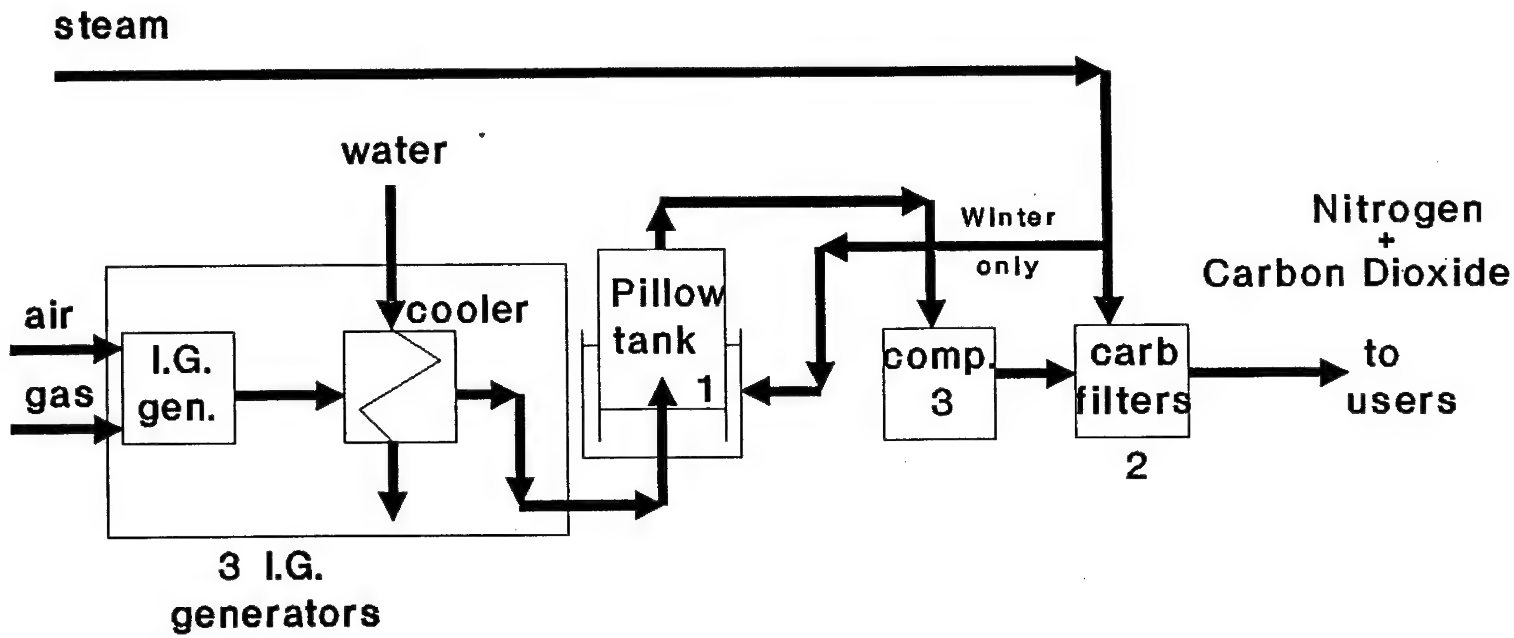


Figure 2-6

eliminate the burning of natural gas completely for this purpose. In addition, some electrical savings are anticipated if the proposed system is installed. Funding for this proposed project cannot be justified solely on energy savings and must rely on reduced labor and maintenance savings along with safety considerations resulting from a higher purity inert gas supply.

2.2.3.4 Plant Water

Water for RAAP is provided by the New River through a series of pumps, water treatment facilities and storage tanks. Water is pumped from the river by pumps located in Building #408 in the Main Plant area to Building #409. This is accomplished using a combination of a turbine plus deep well and booster pumps.

Building #409 is used to filter the river water and distribute it using pumps to the fire, plant and raw water storage tanks and to Building #419.

Building #419 is the drinking water plant. Here the water is treated to drinking quality and pumped to a drinking water storage tank and also directly to various plant locations. The diagram (Figure 2-7) on the following page describes the water flow path.

The major energy users here are electric motors which drive the water pumps. Potential energy savings projects are replacing existing motors with high-efficiency ones, installation of variable frequency drives, load shedding during peak electricity usage, and replacement of incandescent lamps with fluorescents.

RAAP Process Flow Diagram

PLANT WATER

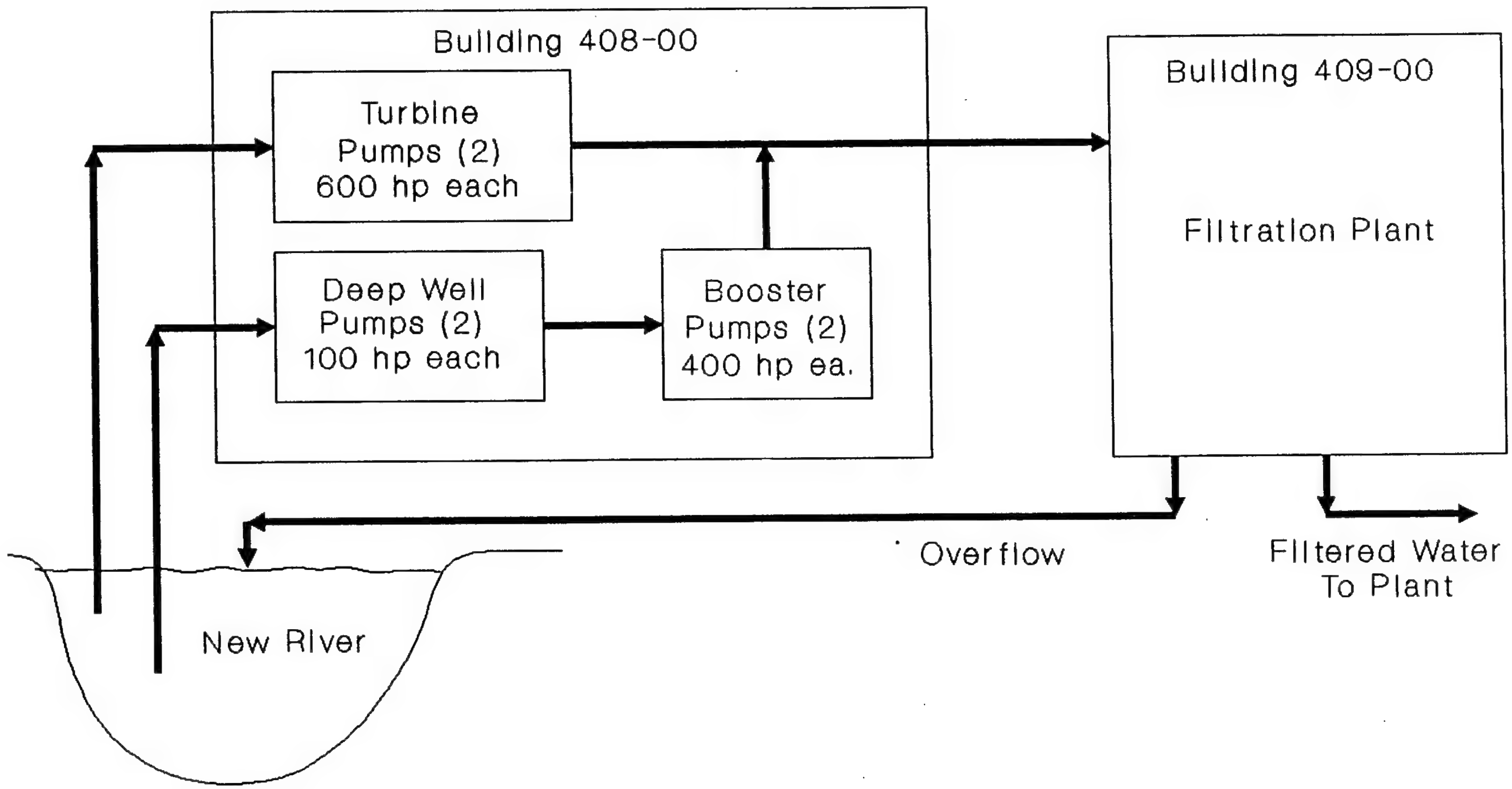


Figure 2-7

2.2.3.5 Wastewater Treatment

There are three types of wastewater treatment facilities at RAAP--waste acid, sanitary sewage and biological.

The Waste Acid facilities are used to neutralize the waste acid from the production lines. They consist of agitation and circulation pumps and motors that add lime as required to the waste acid. The motors utilized are small, in the five- to ten-horsepower range. The agitators and circulation pumps run continuously.

The sanitary wastewater for the main plant is located at Building #424. It consists of large clarification ponds. Clarifier motors run continuously, but are small horsepower. Other pumps are operated intermittently to move water from one pond to another.

The Biological Treatment Plant is located in Building #470. Here pollutants are removed from industrial wastewater. The wastewater is treated by using an aeration basin, rotating biological contactors and an anaerobic sludge digestion system. Water is removed from the sludge with a vacuum filter belt press.

The primary area for energy savings will come from using high-efficiency motors and lighting.

2.2.3.6 Compressed Air

Compressed air is supplied to the main plant area from Building 700. This facility houses eight electrical reciprocating compressors rated at 2,350 cfm each and 120 psig. One of these compressors is no longer in use. Each electrical compressors are each powered by a 500 hp synchronous motor. In addition, there are four energy recovery compressors that utilize 90 psig exhaust compressed air from the AOP. It should be noted that this compressed air contains minute amounts of NO_x and cannot be utilized in the compressed air system for general plant use. Each energy recovery compressor normally produces 750 cfm of compressed air at 120 psig, although actual output is directly related to exhaust air received from the AOP and the rpm setting on the energy recovery units. Compressed air exhausted from the AOP is reduced in pressure to drive these energy recovery units and the resulting lower pressure air is exhausted to the atmosphere.

Typical operation calls for three electrical compressors and two energy recovery machines to be used for the AOP. Three electrical compressors handle the remainder of the plant requirements. See Figure 2-8 for a description of the system layout.

Potential energy savings here are small. The synchronous motors are very efficient and aid plant power factor. The compressor cooling water is a low-grade energy source.

RAAP Process Flow Diagram

MAIN PLANT COMPRESSOR SYSTEMS

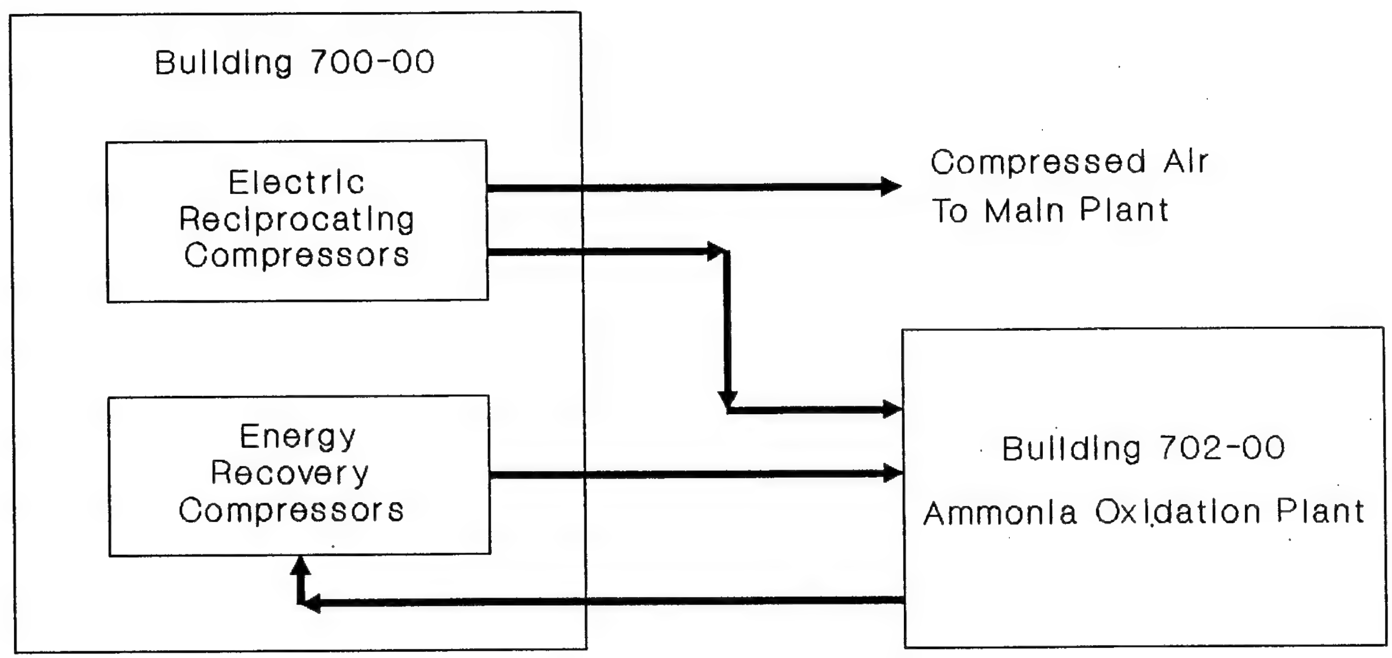


Figure 2-8

2.2.4 Forced Air Dry

There are 21 Forced Air Dry (FAD) houses located in this area which is also called the "Pilot-B" area. The forced air dry process is used to remove excess volatile solvents from multi-base propellants. Also, some single-base products that cannot be processed through the normal Solvent Recovery, Water Dry and Air Dry processes due to physical limitations of propellant size and configuration are processed in the FADs. Solvents typically used in multi-base propellants are nitroglycerin, alcohol, ether and acetone. These solvents are removed by blowing hot air across the propellant and then exhausting the air-solvent mixture to the atmosphere (Figure 2-9).

The FAD houses are divided into four bays. There are two fan-steam coil heating systems that serve two bays (one side of the FAD building) each. Propellant is loaded onto boards or trays and then into the FAD bays. Outside air is heated by the steam coils to maintain the temperature in the bays at 140°F for eight to 200 hours depending on the propellant.

The FAD buildings are big energy users due to the use of 100 percent outside air. Heat recovery or the addition of a return air system would greatly improve the efficiency of these buildings, but the possibility of nitroglycerin condensation forming on the equipment makes these projects impractical from a safety standpoint. A study has been completed to modernize FAD buildings through modifications to supply air ductwork which results in a reduction of supply air from 5,500 cfm to 1,500 cfm per bay. This reduction will save an estimated 34 percent of the present steam usage and 78 percent of the present electrical usage with individual bay controls and supply air modifications (PE-833). This modernization has been completed on two of the 21 FAD buildings.

RAAP Process Flow Diagram

FORCED AIR DRY

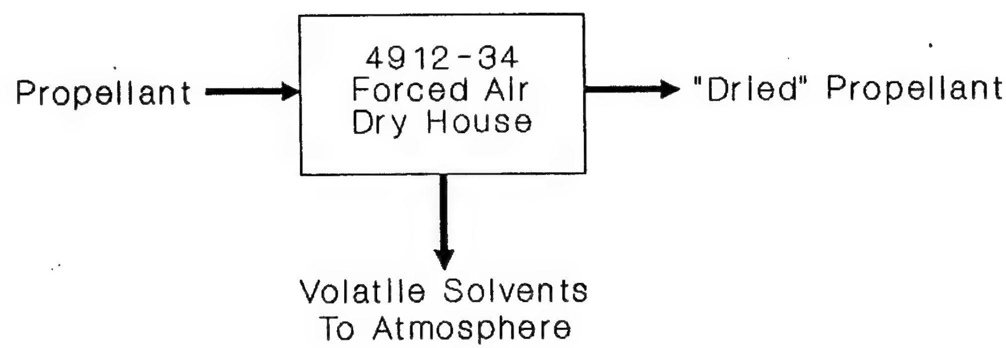


Figure 2-9

2.2.5 Nitrocellulose

Cotton linters and wood pulp sheets are received and stored in the Linter Warehouse (Building #2000). These are taken to Building #2010 where the bales or sheets are ground into small particles. The ground bales/sheets are air conveyed to the continuous NC Nitrator (Building #2045) where they are combined with a mixture of nitric acid and sulfuric acid from the NAC/SAC (Figure 2-10) and processed to form nitrocellulose.

The nitrocellulose (NC) solution is sent to a series of three buildings for purification and refinement. These are the Boiling Tub House (#2019), Beater House (#2022) and Poacher and Blending House (#2024). The NC undergoes a number of boiling and wash cycles in the Boiling Tub operation (#2019) and is then pumped to the Jordan Beaters (#2022). Here the NC goes through a series of cutting processes. The NC is pumped to the Poacher and Blending House (#2024) for the final boiling and decanting process. From here, the NC is taken to the Wringer House (#2026) where the solids are centrifugally separated from the liquid constituents. The NC at this point is primarily a solid and is taken to the Green Line solvent propellant area and Building #2500, the Dehy Press. The primary targets for potential energy savings are the Boiling Tubs and Poachers which use large amounts of thermal energy.

RAAP Process Flow Diagram

NITROCELLULOSE

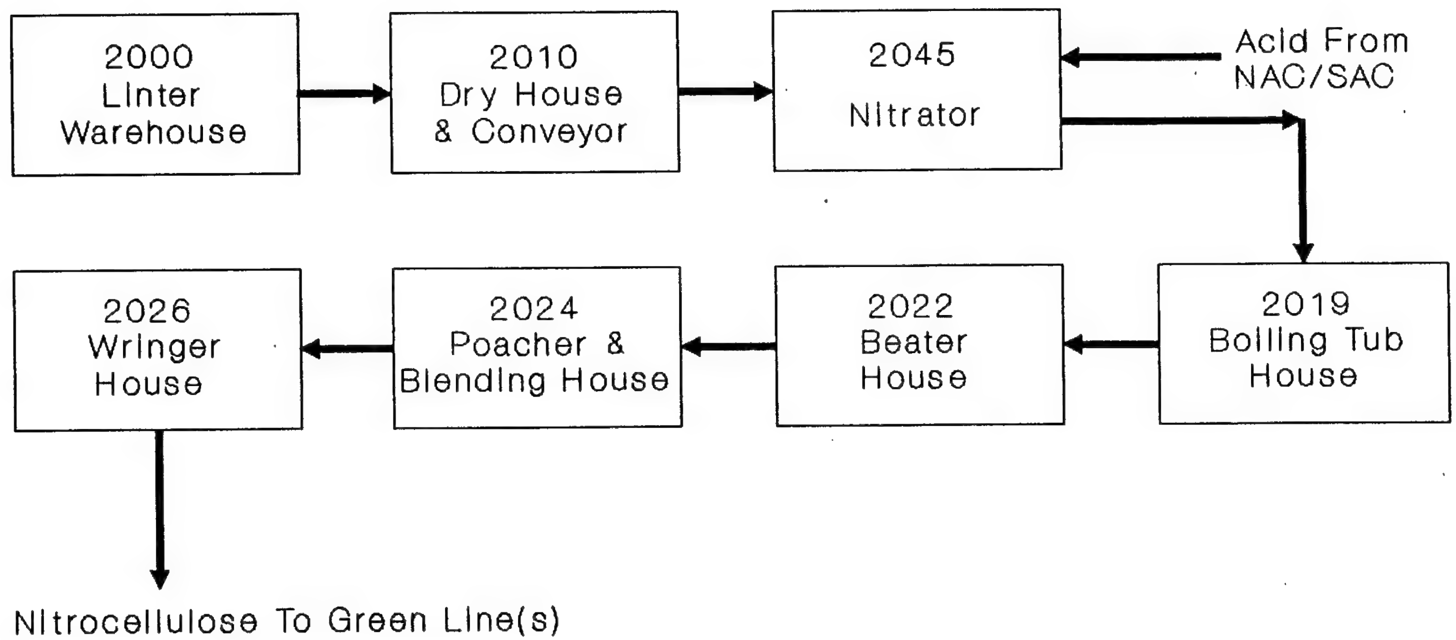


Figure 2-10

2.2.6 Green Line Solvent Propellant

The process flow diagram for the Green Line area is shown in Figure 2-11. The Dehy Press operation forms the loose NC from the Final Wringer into a solid cylindrical block using a hydraulic press. Alcohol is injected into the loose NC as it is pressed. The pressed block is taken to the Mix House (#2508) where the block is broken and mixed with various other chemicals necessary for propellant manufacture. Following the mixing process, the propellant mixture is preblocked, macaronied and final-blocked (Building #2510) before being taken to the final press operation. The macaroning step presses the preblocked material into rope-like strands which are collected and blocked again in the final blocking step. The macaroni-blocking operation provides secondary mixing for those single-base propellants that require this process step.

The blocked propellant mix is then processed through the final presses (Building #2516). The final pressing operation consists of pressing the blocked propellant mixture through extrusion dies which forms the propellant into strands. The propellant strands are then processed through the cutting machines in which the propellant is cut to the required lengths.

RAAP Process Flow Diagram

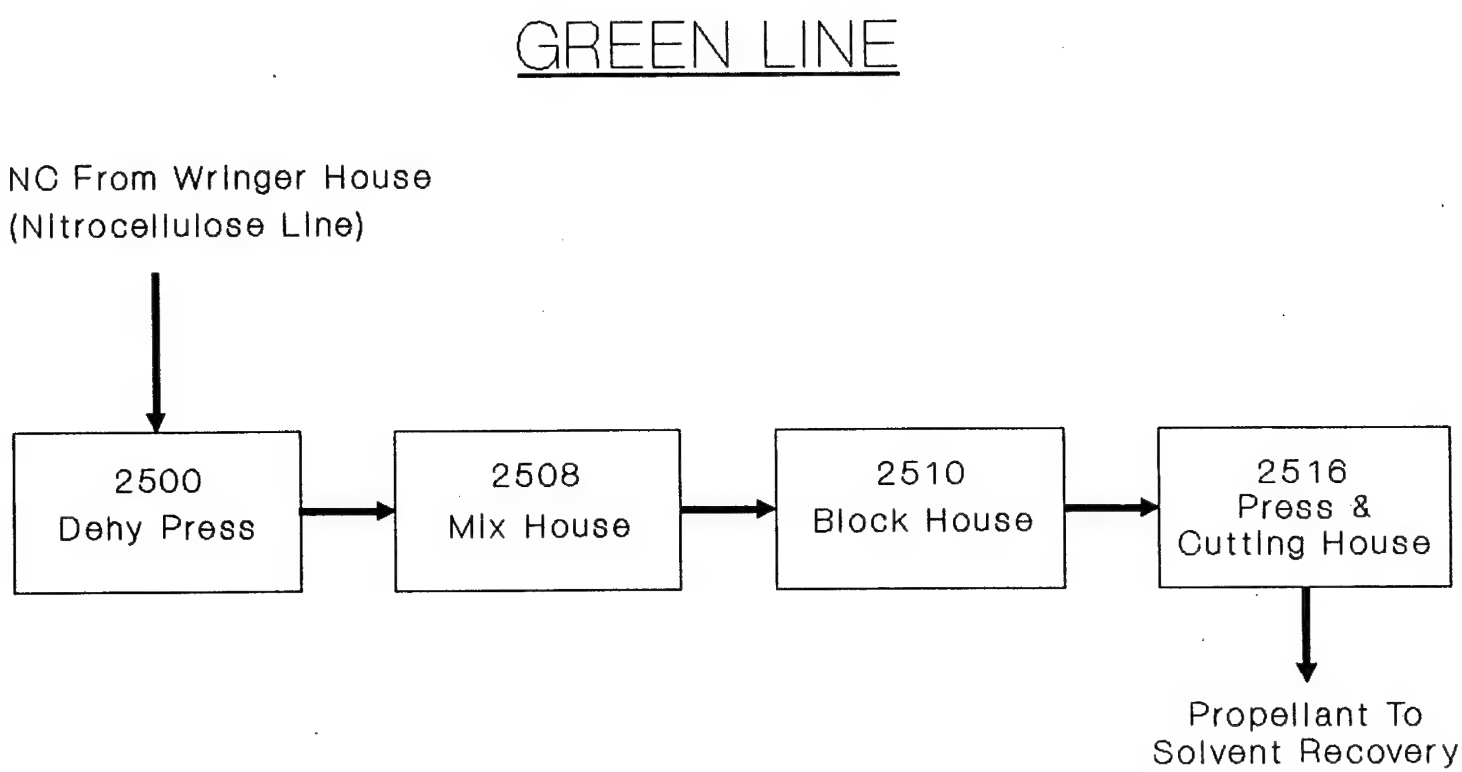


Figure 2-11

2.2.7 Nitroglycerin

The process flow diagram for nitroglycerin operations is shown in Figure 2-12. Glycerin is nitrated with a mixture of nitric and sulfuric acids. The nitration temperature is controlled using a brine solution. The nitroglycerin (NG) is then transferred by eduction to storage. From storage, the NG is transferred to slurry mix, or to master mix. At master mix, other chemicals are added and the master mixes may be used for slurry or premix, or solvent casting liquid for use in the rocket grain manufacturing operations.

Due to the hazardous nature of NG production, energy savings potential is minimal.

RAAP Process Flow Diagram (as of 12/90)

NITROGLYCERIN

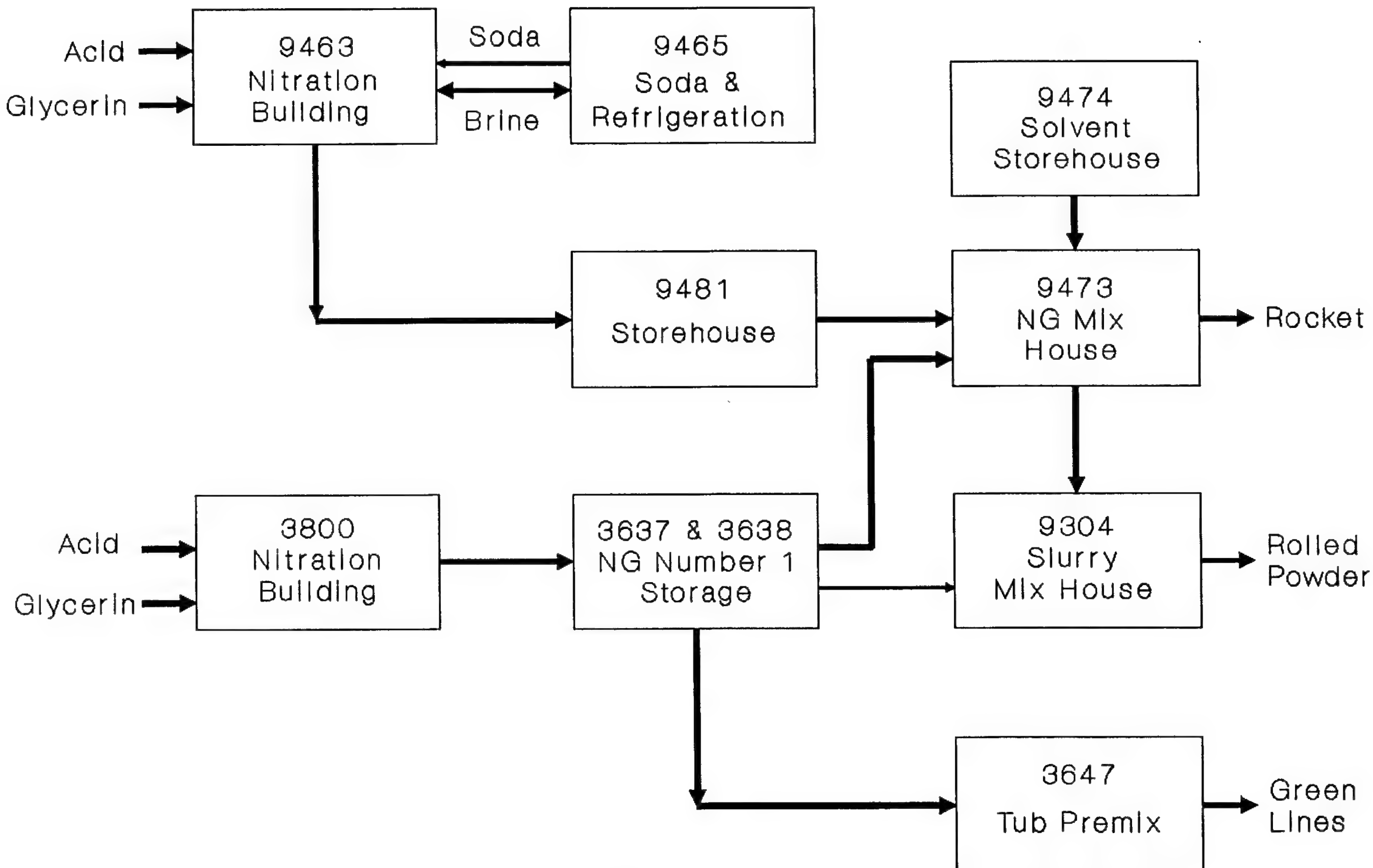


Figure 2-12

2.2.8 Rocket

Within the Rocket Area, two types of rocket propellant grains are manufactured, cast and extruded. In addition, the igniter line is located in the Rocket Area. Also, at present, one type of granular propellant is extruded in this area. The steam energy intensive part of these manufacturing processes is the rocket grain curing and carpet roll conditioning houses, which are similar to the Forced Air Dry houses. Most of the other buildings in these areas are maintained at 70°F and 50 percent relative humidity for the rocket propellant. The air conditioning systems for these buildings consume a considerable amount of electricity, particularly during the summer months.

The first step in the casting process (Figure 2-13) is inspection of parts and preparation of the mold assembly. The mold is then filled with base grain which is manufactured at RAAP. Casting liquid is drawn into the mold as a result of negative pressurization. This is the actual casting process, and it is done remotely from a control house. The cast propellant is then cured at 145°F for 96 hours. After curing the molds are disassembled, the cast propellant is then cut to length on a billet saw, faced on a lathe, an end inhibitor is glued on, and a hole is bored and coned on a lathe. These sawing and machining operations use water to remove the propellant shavings. This moisture is removed in the drying process. The final step is inspecting the propellant and packing it for shipment.

The Extruded rocket process (Figure 2-14) starts in the press houses where carpet rolls from the Rolled Power area is extruded and cut to the required length. the extruded propellant is then annealed in a curing house at 165°F for eight to 30 hours to relieve stresses caused by the extrusion process. After annealing the propellant is inspected by fluoroscope for imperfections, the end is then milled, the propellant is cut to length and an

RAAP Process Flow Diagram

EXTRUDED ROCKET

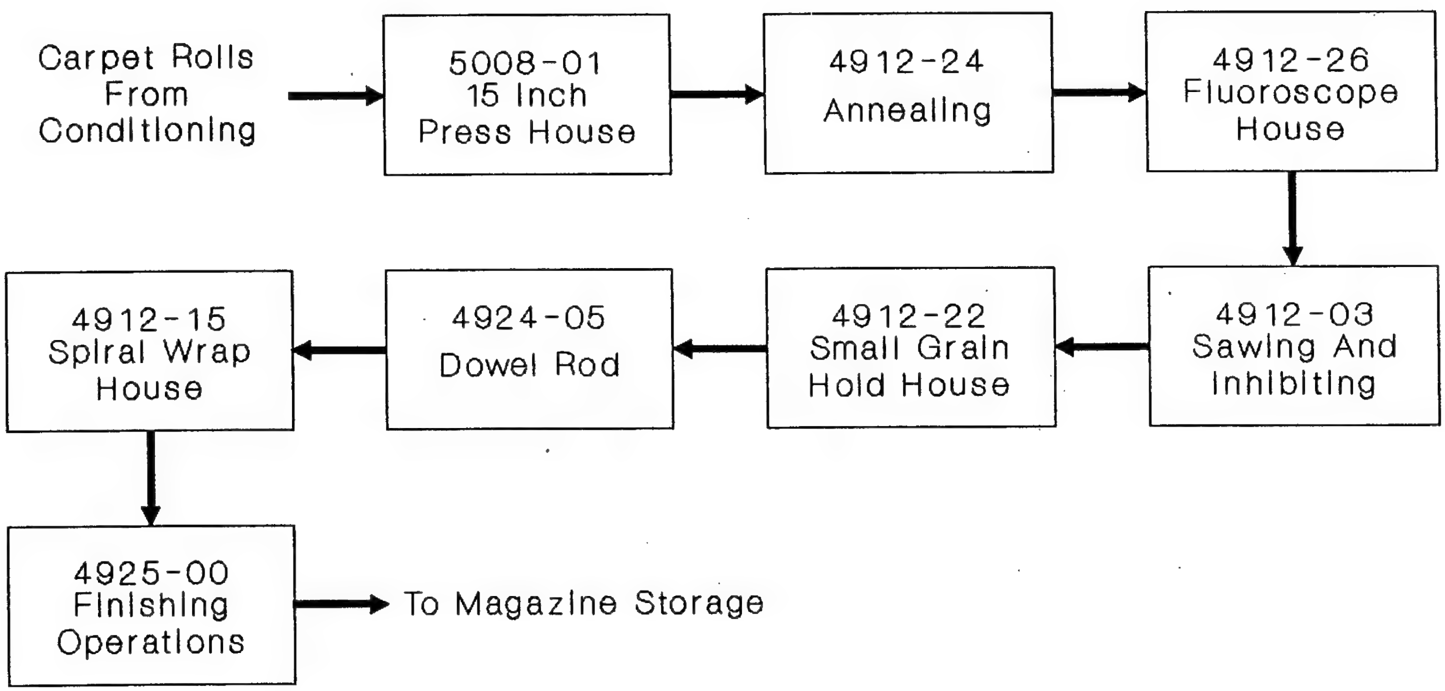


Figure 2-13

RAAP Process Flow Diagram

CAST ROCKET

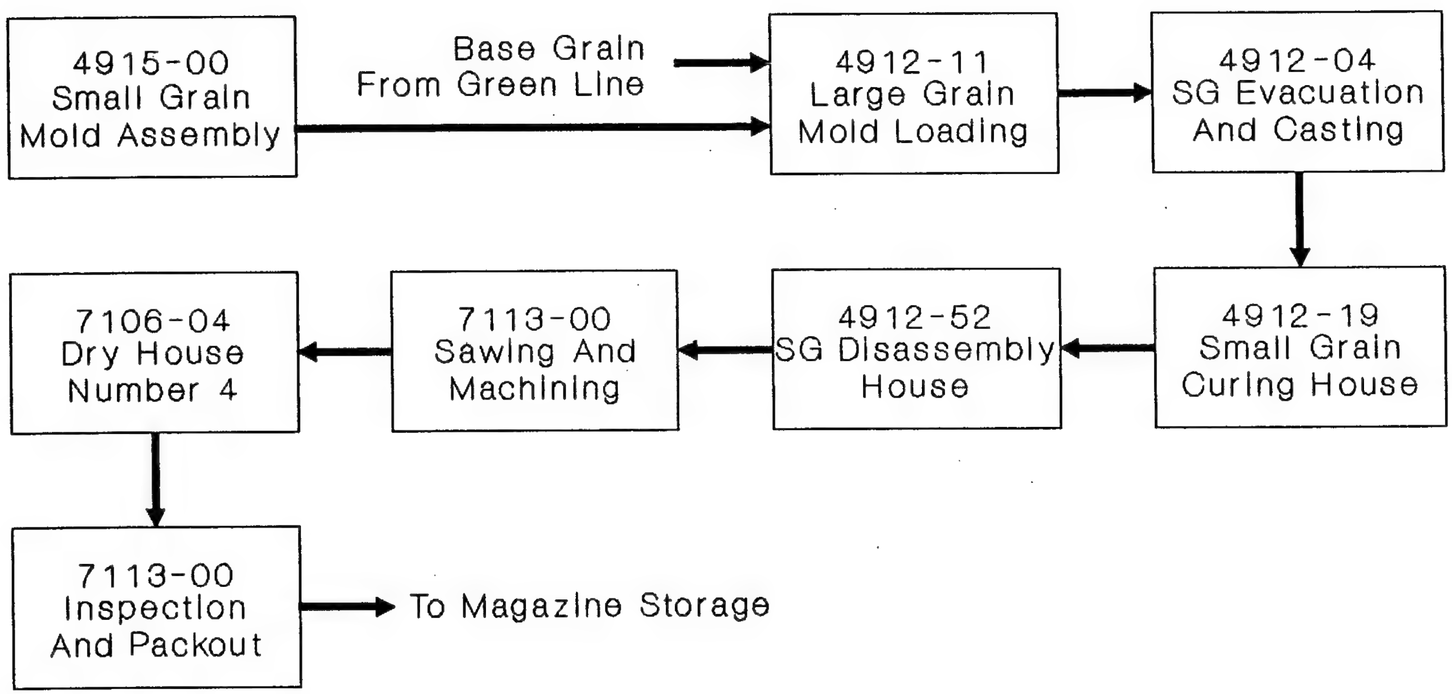


Figure 2-14

end inhibitor is glued on. The diameter is then milled down in a three-step process located in the Dowel Rod Building. The spiral wrap process then puts inhibitor tape around the grain so that it will burn from the inside out. The propellant is then conditioned at 70°F for 16 hours, goes through four more minor finishing operations and is inspected and packed out.

The igniter line is a manual assembly and inspection process. The main energy use is for space conditioning and lighting.

2.2.9 Rolled Powder

There are two rolled powder areas at Radford AAP; First Rolled Powder and Fourth Rolled Powder (Figure 2-15). First and Fourth Rolled Powder areas produce solventless propellants as both finished products and intermediate materials. Mortar increments, M31A1E1 stick propellant and LAW charges are also processed in these areas.

The carpet roll production process starts with a nitrocellulose and nitroglycerin paste mixed from slurry produced in the NG-2 area. This paste is blended with other chemicals in a hydraulic drive 800-pound capacity blending drum. To produce carpet rolls for extruded grains or for off-plant shipment, the paste is subjected to two rolling processes, a preroll and evenspeed roll. In the rolling process, the propellant is rolled between cylindrical, heated rolls. The slitting and creation of the final carpet roll is then performed in the slitter/carpet roll machine. The carpet rolls are then inspected and packed out.

The increment production process starts the same way as the carpet roll process. After the preroll and evenspeed roll, the propellant goes through a final roll and a shear press to trim the edges. The sheets are sewn together into pads, the pads cut up into squares, and holes are punched into each square increment. The increments are then weighed and sorted, and packed out to the magazine area to await shipment.

The major energy consumer for these processes is steam used for heating process hot water and building space conditioning. The preroll, evenspeed and final rolls are heated by hot water from dedicated steam-to-hot water converters. Propellant sheet cabinets and certain metal table tops that are in contact with propellants or are used for propellant storage are also heated with hot water from these converters.

RAAP Process Flow Diagram

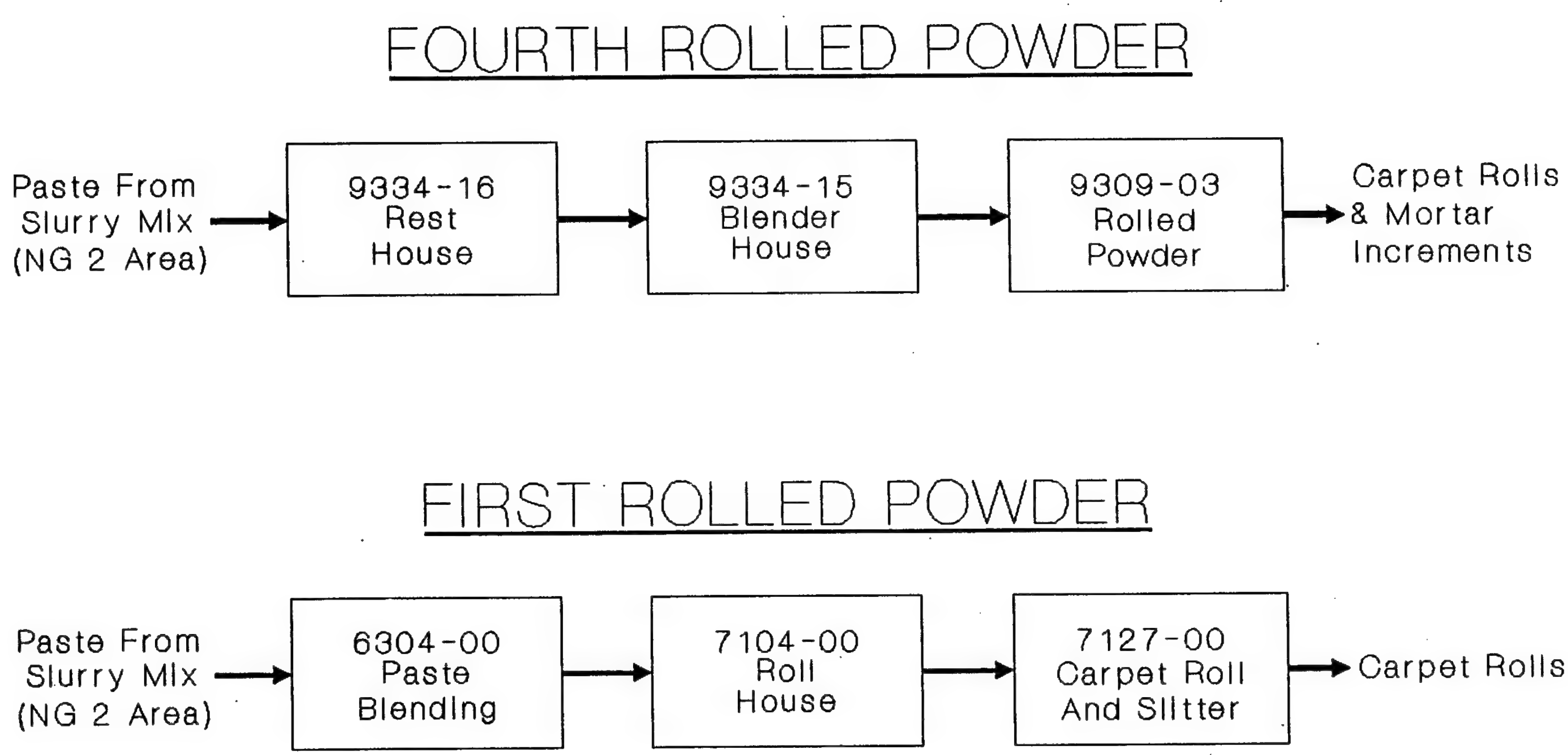


Figure 2-15

2.2.10 Solvent Recovery

The solvent recovery process is designed to remove and recover the ether and alcohol that has been added to the propellant. There are 27 Solvent Recovery Buildings. Only 15 of these buildings are currently active.

Each building has five insulated tanks which are approximately six feet high with a ten-foot diameter. Between 5,000 and 7,000 pounds of propellant is loaded into each tank as a batch process. Each batch is subjected to the solvent recovery process for 26 to 118 hours depending upon the type of propellant (Figure 2-16).

Inert gas is heated to 120°F $\pm$ 25°F by steam coils and circulated through each tank by individual three-horsepower blowers. The inert gas absorbs the solvents from the propellant, is drawn off the top of the tanks, and passes through a water-cooled coil to condense out the solvents. Depending on the temperature of the river water, either filtered water or chilled water is used in the condenser to cool the inert gas to about 60°F. The condensed solvents are collected in tanks outside of each building until being pumped to the solvent still area for processing.

The potential energy savings opportunities for the solvent recovery area include energy efficient motors and more efficient lighting systems.

RAAP Process Flow Diagram

SOLVENT RECOVERY

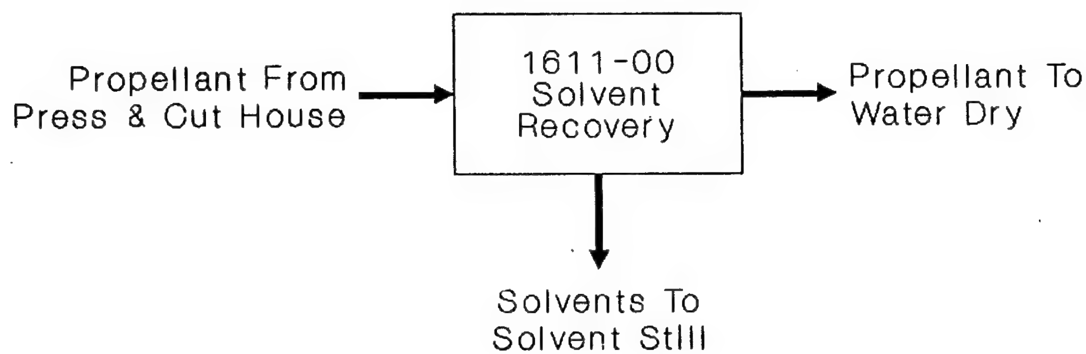


Figure 2-16

2.3 Historical Energy Use

Figure 2-17 shows the energy use and cost at RAAP from fiscal years 1985 to 1989. Both energy use and cost display a downward trend. This correlates well with decreased nitrocellulose production rates over the same time period (Figure 2-18). The results of a detailed regression analysis on how production and weather affect energy use at RAAP are contained in Section 2.4.

Figures 2-19 and 2-20 show the distribution of energy use and cost, respectively, by fuel type. Coal dominates both pie charts at 87 percent on a Btu basis and 61 percent of the total utility bill. RAAP purchases approximately $6,000,000 in coal annually and is probably the single largest coal consumer among U.S. Army installations! RAAP is also one of the few installations that generates its own electricity. Typically, RAAP generates about one-half of its electricity. However, power house incidents in FY 89 have temporarily halted electrical power generation during CY-1989 and CY-1990. Current power generation levels are temporarily reduced until Power House modifications are completed.

Figures 2-21 through 2-24 show how the energy use varies throughout the year. Weather definitely influences coal consumption which is demonstrated by a doubling of use during the winter months. Electricity does not appear to have any definite seasonal trend. This is expected, since there is little space cooling at RAAP. Fuel oil and natural gas are minor contributors to the RAAP annual bill at ten percent and one percent, respectively. Fuel oil is utilized in Power House No. 1, explosive waste incinerators, molecular sieve NO_x abatement facility, for heating of one isolated area office and for heating of Family Housing quarters. Natural gas is used at the inert gas plant, the NAC/SAC and at the decontamination ovens.

Radford Army Ammunition Plant

Historical Energy Use & Cost

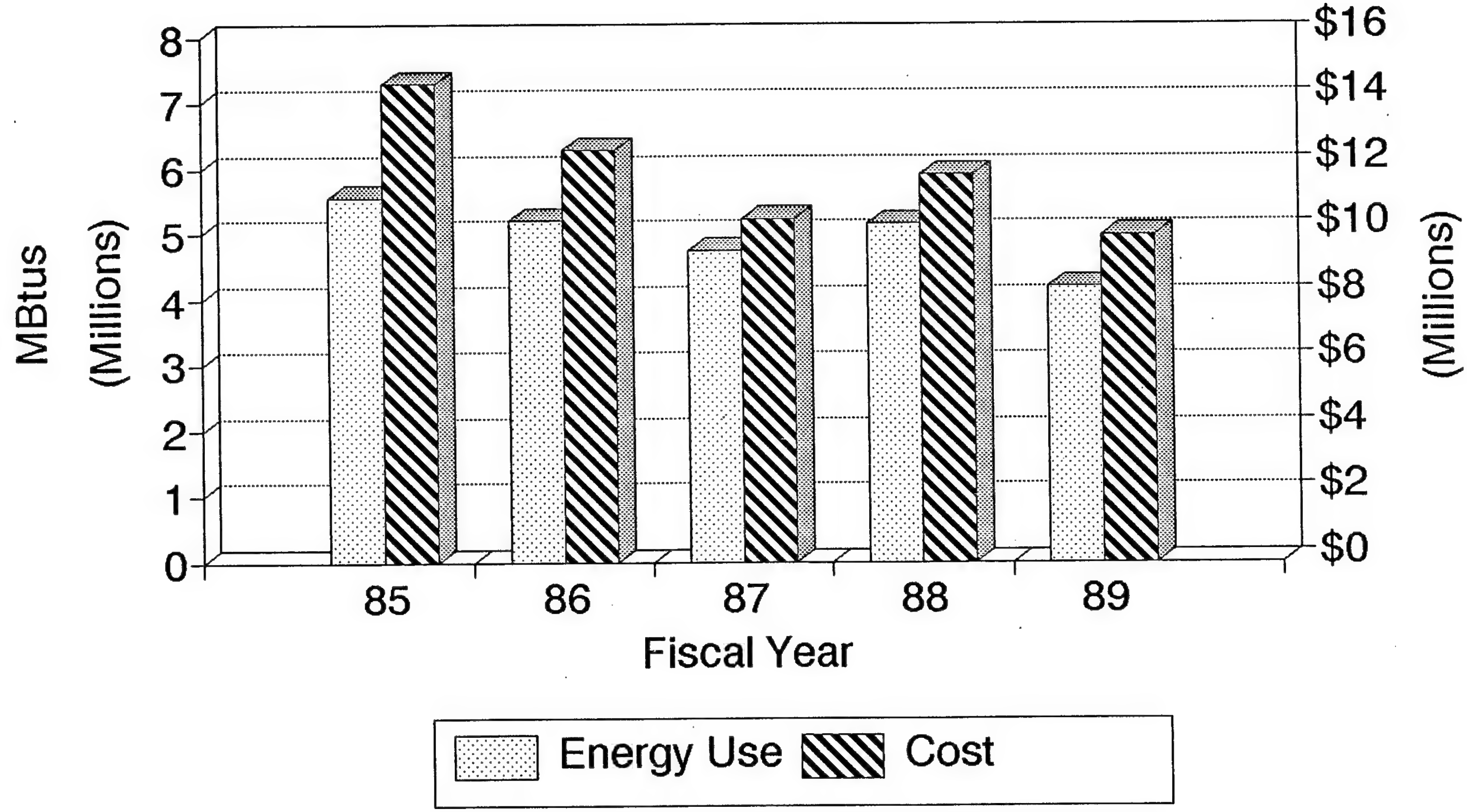


Figure 2-17

Radford Army Ammunition Plant

Historical NC Production

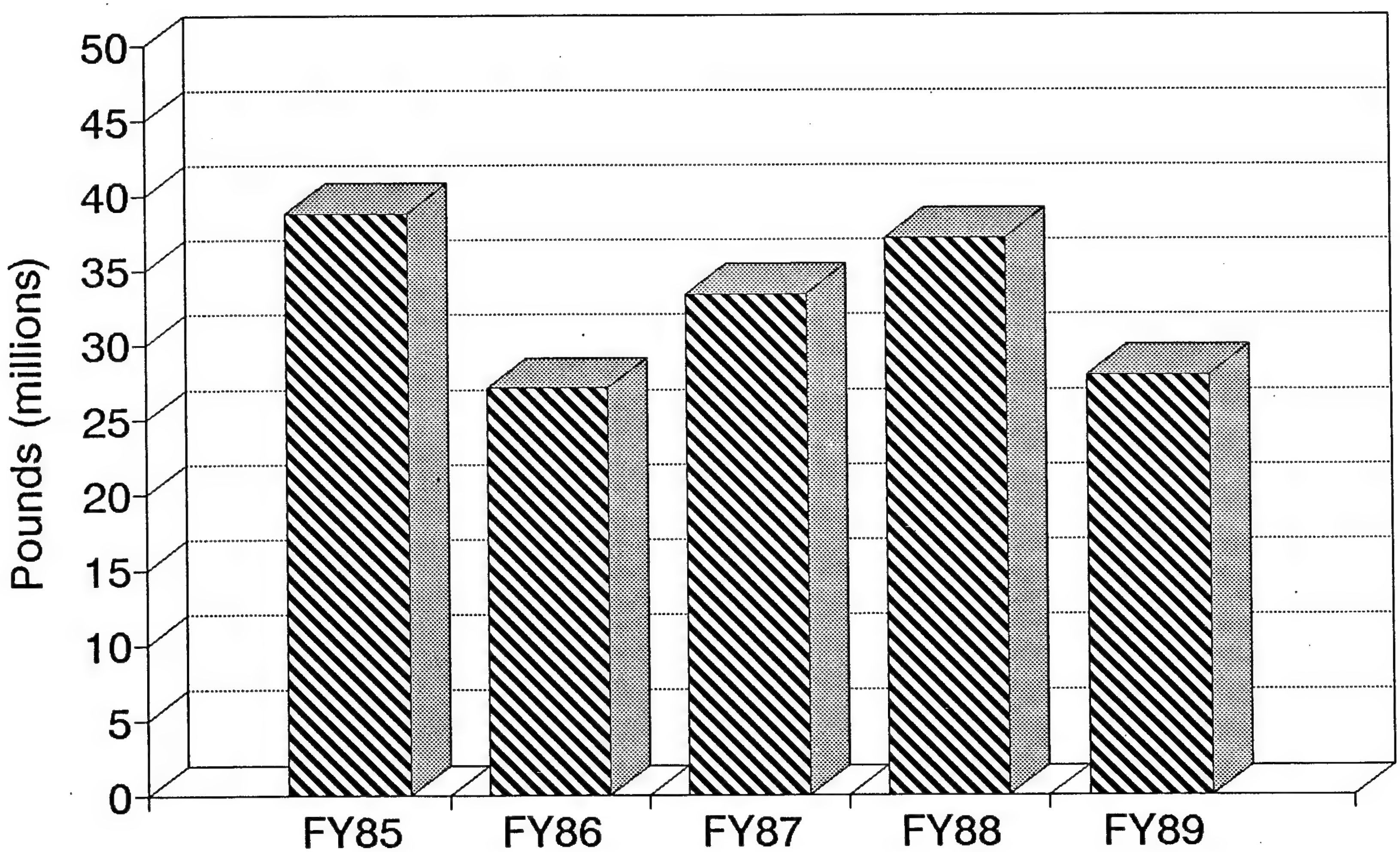
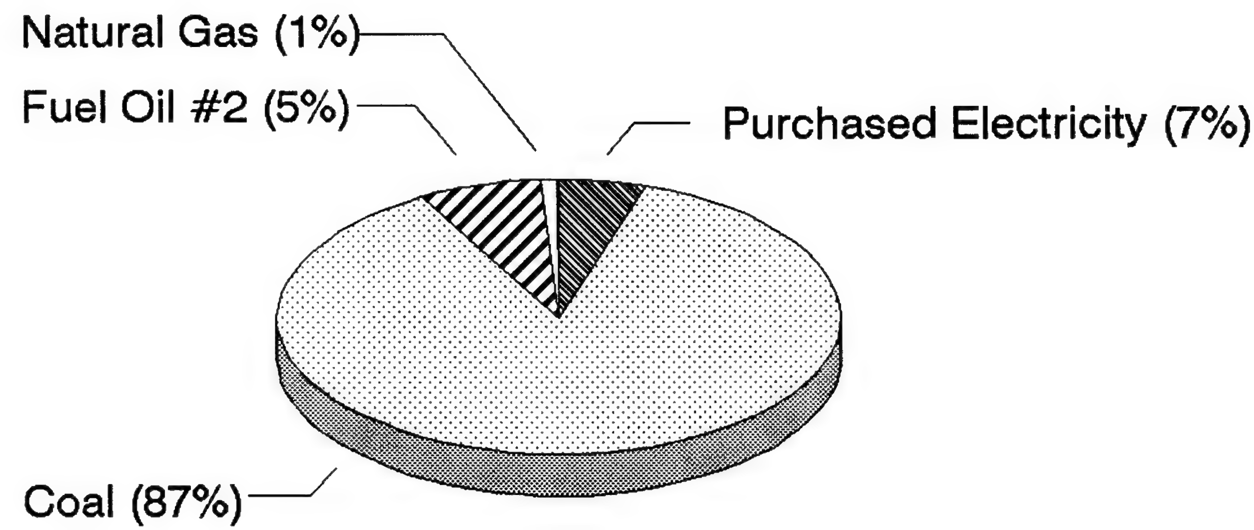


Figure 2-18

Radford Army Ammunition Plant

FY 89 Energy Use by Type



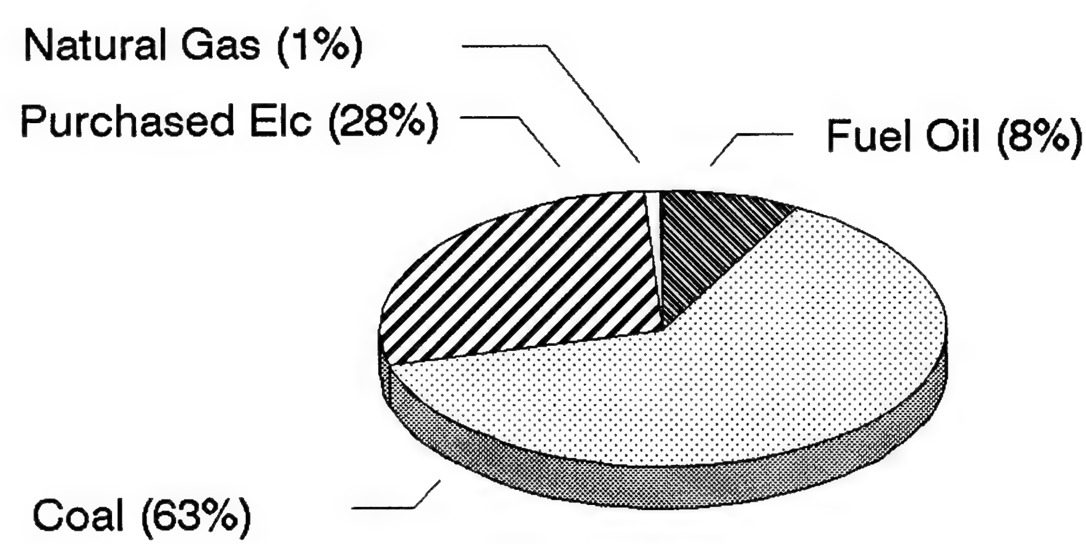
Total Use = 4,177,276 MBtu

Does not include mobility fuels.

Figure 2-19

Radford Army Ammunition Plant

FY 89 Energy Cost by Type



Total Cost = $ 9,655,878

Does not include mobility fuels.

Figure 2-20

Radford Army Ammunition Plant

FY 89 Coal Consumption

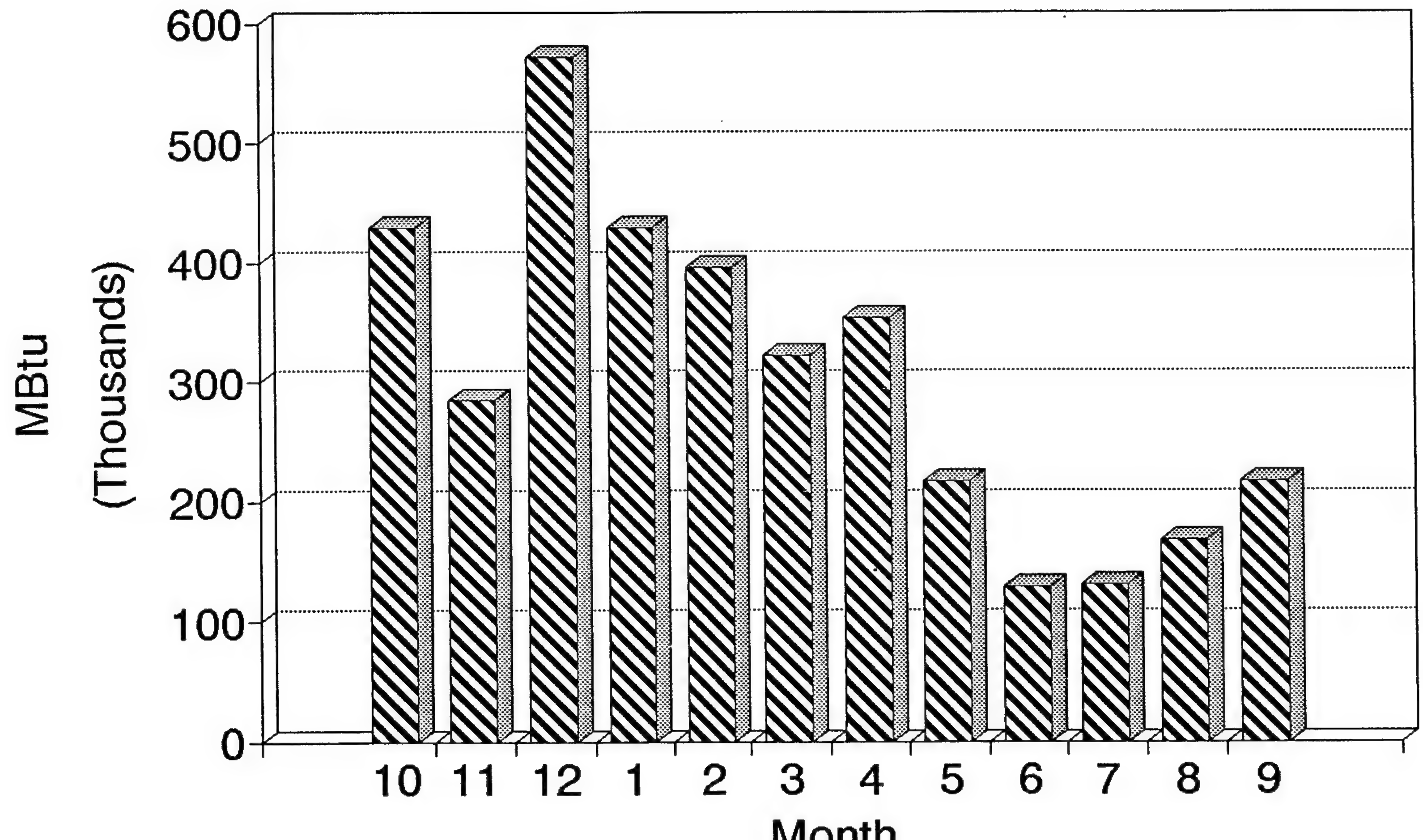


Figure 2-21

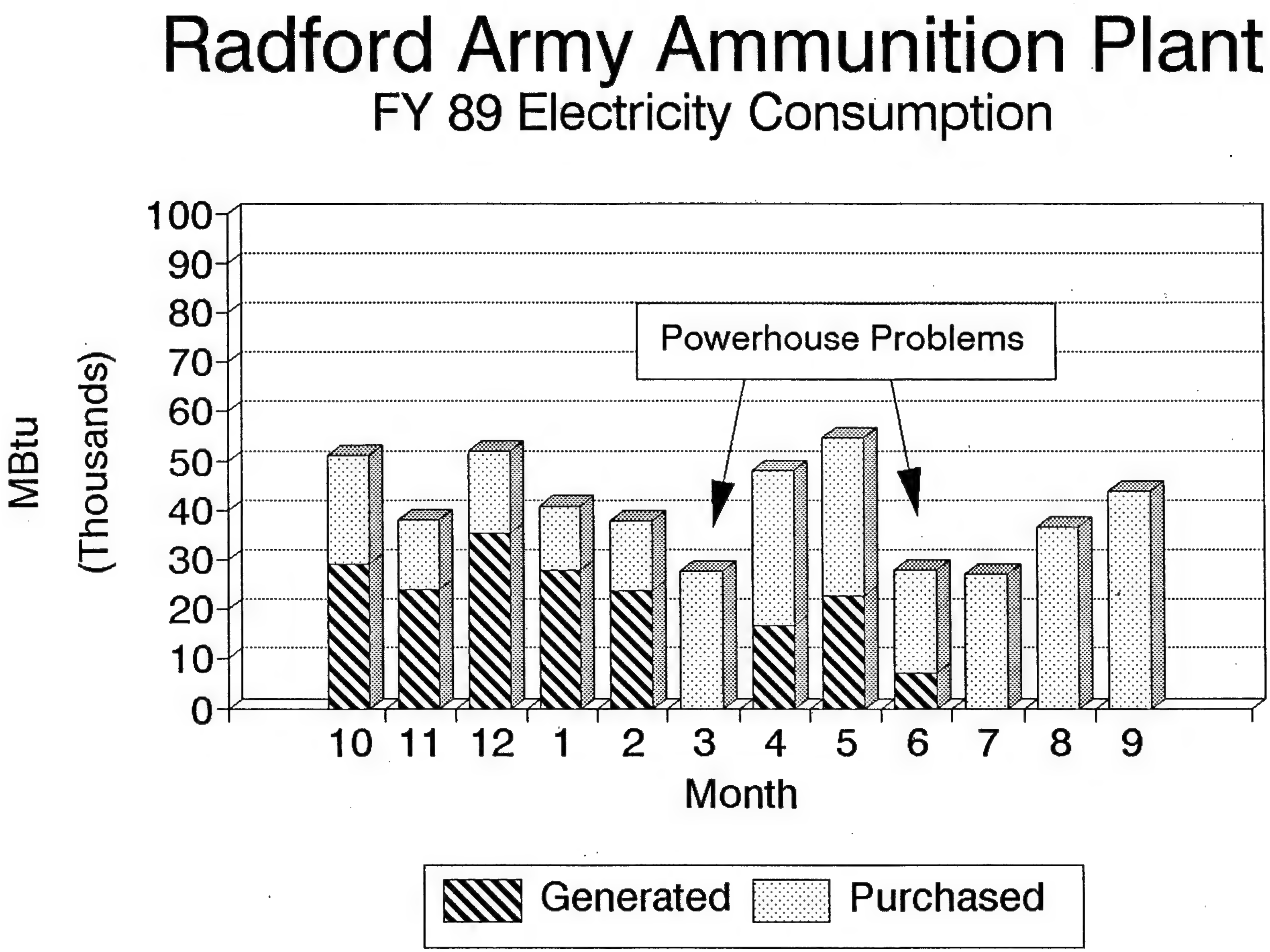

Radford Army Ammunition Plant
FY 89 Electricity Consumption
MBtu (Thousands)
100
90
80
70
60
50
40
30
20
10
0
Powerhouse Problems
10 11 12 1 2 3 4 5 6 7 8 9
Month
Generated
Purchased

Figure 2-22

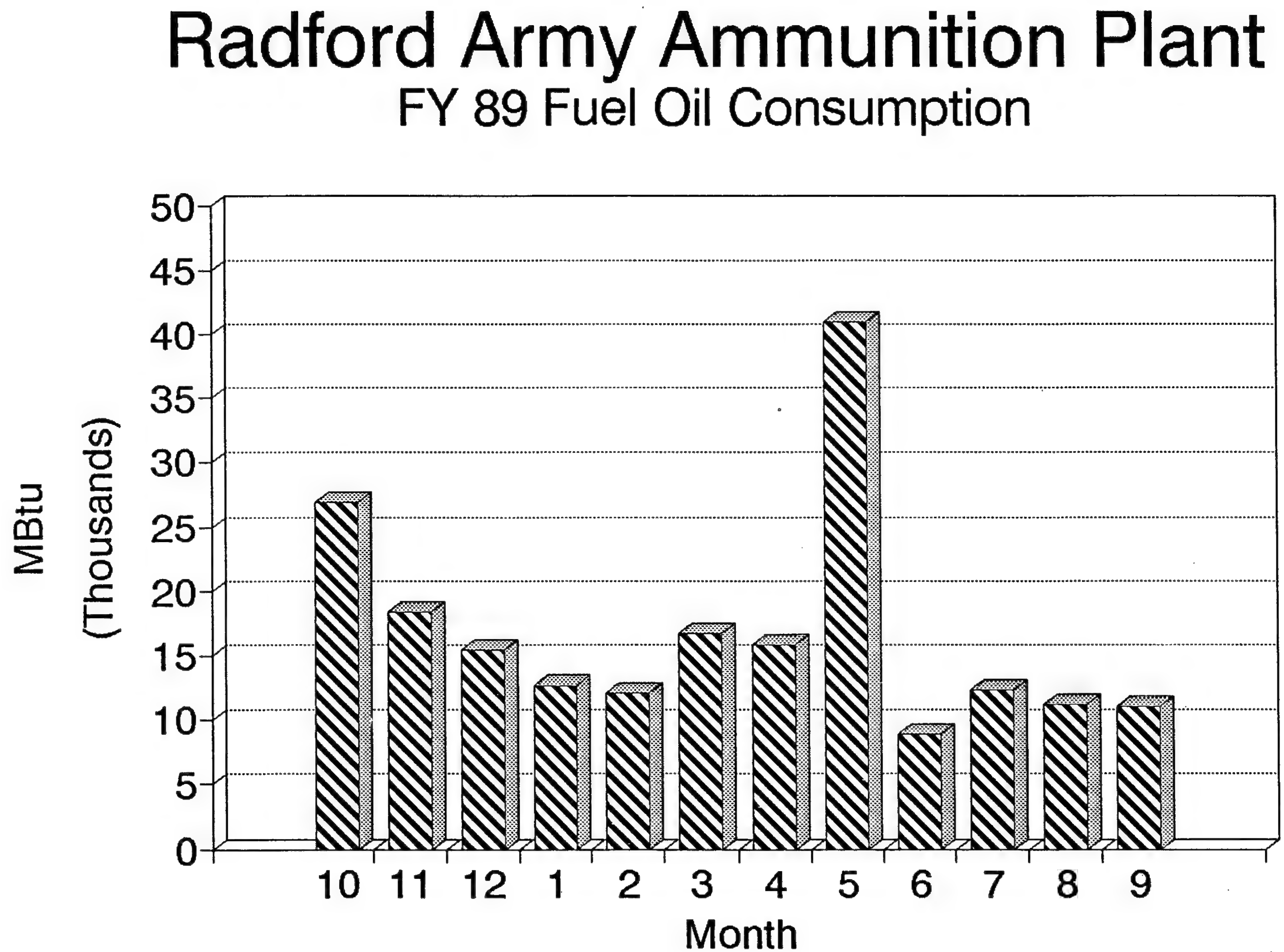

Radford Army Ammunition Plant
FY 89 Fuel Oil Consumption
MBtu
(Thousands)
0
5
10
15
20
25
30
35
40
45
50
10
11
12
1
2
3
4
5
6
7
8
9
Month

Figure 2-23

Radford Army Ammunition Plant
FY 89 Natural Gas Consumption

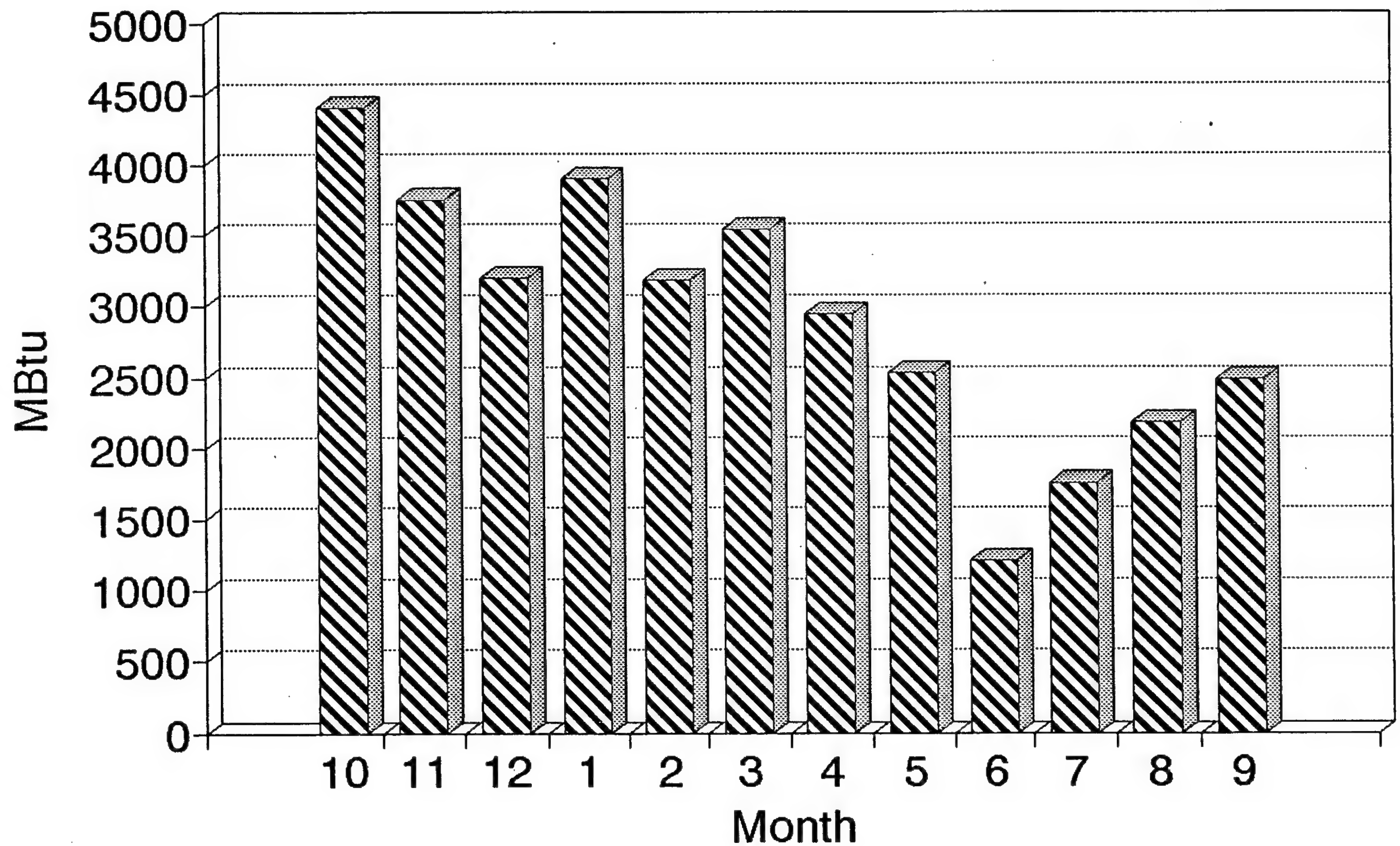


Figure 2-24

Average energy prices are shown in Figure 2-25. RAAP is fortunate that their two largest energy sources, electricity and coal are relatively inexpensive. Electricity is about one-half the price of the average U.S. Army installation. Also, most installations pay more than twice the $1.61/MBtu price for heating fuel, usually in the form of fuel oil or natural gas.

Figure 2-26 shows peak electrical demand at RAAP for FY 88. There is very little variation throughout the year, which is expected since there is little space cooling. Daily electrical demand profiles for RAAP were also studied and are located in Appendix B. These data were for a week in November 1989 (during the period of the turbine generator shut down) and show the entire plant demand. These curves do not show the typical daytime peak which is characteristic of many Army installations. Electricity is heavily dependent on production rates which varies throughout each 24-hour period. This demand curve shape makes peak shaving or demand limiting ECOs unlikely.

RAAP also has an extensive metering program. There are more than 80 electricity meters and steam use meters throughout the installation. Plant personnel use these meter readings to allocate energy use in the different production areas and also to determine if energy consumption or energy costs can be reduced. An analysis of these data was performed to estimate where the energy is used at RAAP. Fuel use amounts were analyzed and assigned to one of the six categories listed in Table 2-1. Plant utilities include Plant Water and Air and Cast Water and Air and the power houses. Steam consumption in Power House No. 1 is credited toward the generation of electricity (599,111 MBtu) based on power generation at 29 percent efficiency, and then allocated among the six categories. Table 2-1 shows the energy use breakdown by use and cost for FY 89. Data and analysis calculations used to produce this table are located in Appendix B.

Radford Army Ammunition Plant

FY 90 Average Energy Unit Prices

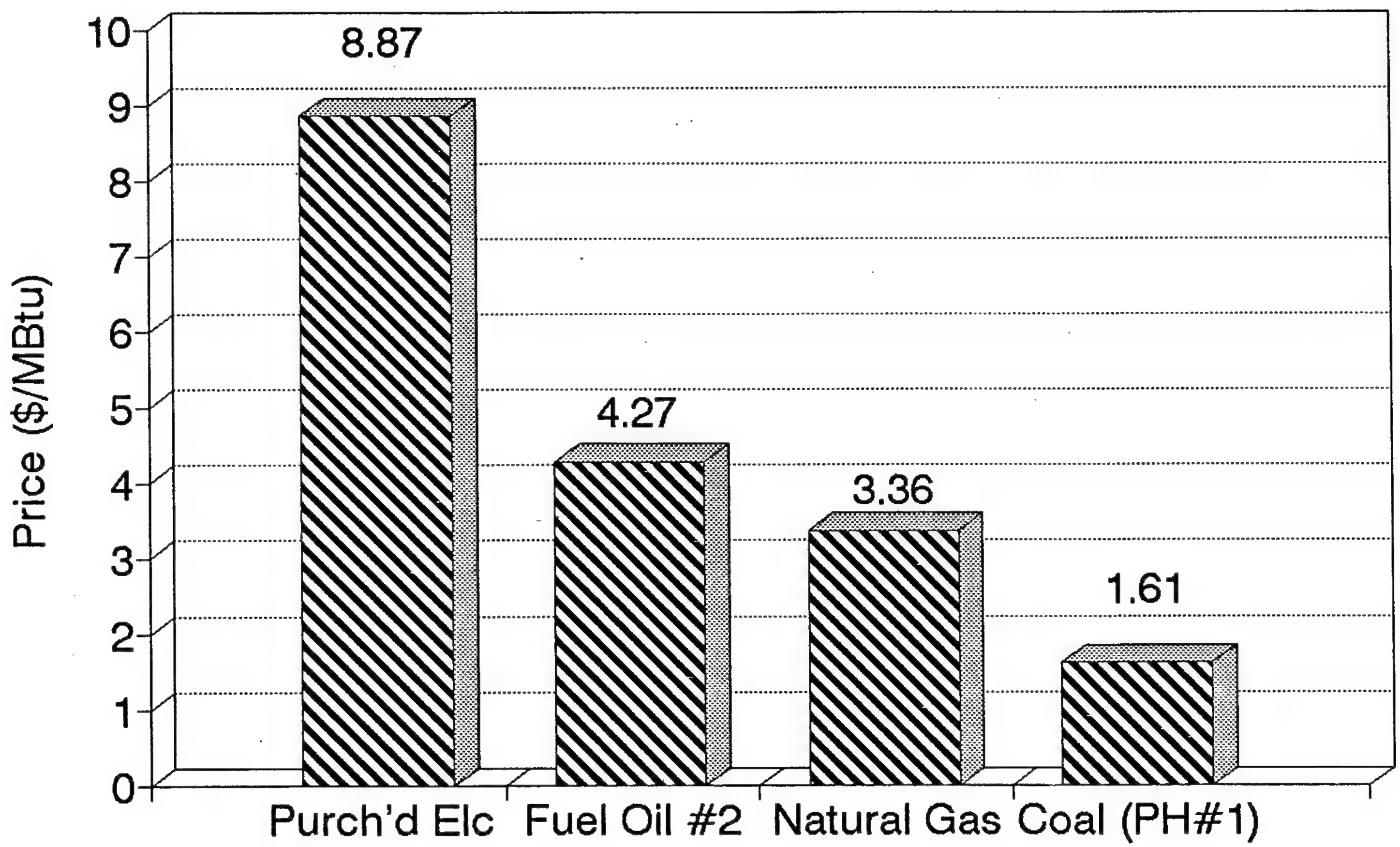


Figure 2-25

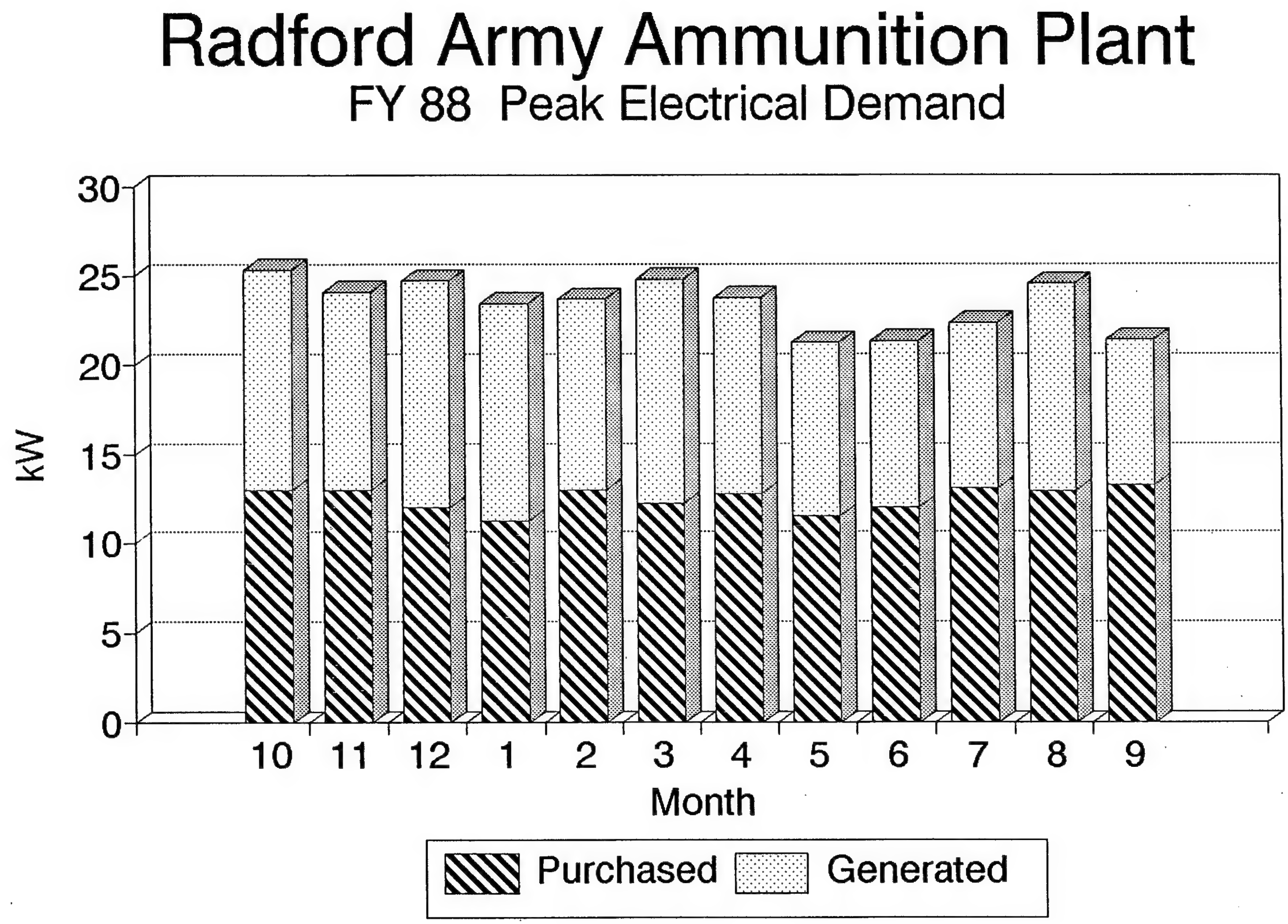

Radford Army Ammunition Plant
FY 88 Peak Electrical Demand
kW
30
25
20
15
10
5
0
10
11
12
1
2
3
4
5
6
7
8
9
Month
Purchased
Generated

Figure 2-26

TABLE 2-1. RADFORD AAP ENERGY USE - FY 89

FUEL TYPE	ENERGY USE MBTU	ENERGY USE $	END USERS: ADM & BLDG HEAT	PLANT UTILITIES	PROCESS: ACID & NC	PROCESS: SOLVENT	PROCESS: S'LESS	PROCESS: OTHER
COAL (1)			111,700	-	1,050,083	705,066	1,033,875	139,111
Steam	3,039,835	$5,076,525	$186,539	-	$1,753,639	$1,177,460	$1,726,572	$232,315
Electricity	599,111	$1,000,515						
			78,144	214,451	232,580	158,211	161,668	54,272
PURCHASED			$313,105	$859,251	$931,891	$633,913	$647,764	$217,456
ELECTRICITY	300,215	$2,602,864						
			1,719	119,617	-	-	-	81,144
FUEL OIL #2	202,480	$857,843	$7,283	$506,781	-	-	-	$343,780
			-	-	8,507	23,608	-	2,986
NATURAL GAS	35,101	$115,131	-	-	$27,904	$77,433	-	$9,794
			-	-	-	-	-	534
PPG	534	$3,000	-	-	-	-	-	$3,000
TOTALS	4,177,276		191,563	334,068	1,291,170	886,885	1,195,543	278,047
			4.6%	8.0%	30.9%	21.2%	28.6%	6.7%
TOTALS		$9,655,878	$506,927	$1,366,032	$2,713,434	$1,888,806	$2,374,336	$806,345
			5.2%	14.1%	28.1%	19.6%	24.6%	8.4%

(1) Total coal = 3,638,946 MBtu and $6,077,040

The results show that about 81 percent of the energy on a Btu basis and 86 percent on a cost basis is directly used in production. The most energy intensive production areas are the acid and nitrocellulose areas.

2.4 Energy and Production Data Analysis

2.4.1 Computer Modeling

Historical energy consumption at Radford Army Ammunition Plant (RAAP) was analyzed to determine the dependency of primary energy use on variables that affect that use. In an industrial plant such as RAAP, these variables may be production end items, components of end-item production, number of employees, weather, or a combination of any of the above.

In 1986, USA-CERL published a report for DARCOM (Technical Report E-86/02, March 1986) that attempted to quantify the dependence of monthly total energy consumption, heating fuel use and electricity use on certain variables. Eight years of monthly data from FY75 through FY82 were analyzed using regression analysis with the following results for RAAP.

Total Energy

$$\text{MBtu} = 32{,}141.99 + 172.14\ \text{HDD} + 19.37\ \text{ESBP} + 75.63\ \text{LBRFRC} \quad (1)$$

$$R^2 = 0.871$$

Heating Fuels

$$\text{HTGF} = 125{,}008.15 + 155.21\ \text{HDD} + 22.09\ \text{ESBP} \quad (2)$$

$$R^2 = 0.839$$

Electricity

$$\text{ELEC} = -4{,}063.19 + 4.16\ \text{LBRFRC} \quad (3)$$

$$R^2 = 0.759$$

Where:

HDD = heating degree-days

ESBP = equivalent single-based product

LBRFRC = labor force

R^2 = statistical correlation measurement (explained below)

2.4.2 Linear Regression Analysis

Regression analysis is a statistical method for determining the dependence of a variable on one or more independent variables that affect the magnitude of that quantity. The theory of regression analysis rests upon the treatment of the data such that the sum of the squares of the error between the calculated values and the observed values of the dependent variable are minimized. There are certain statistical quantities that measure the accuracy of the regression equation; the most common is the quantity R^2, which measures the percentage of the variation of the dependent variable that is explained by the regression equation. In the equations developed by CERL, for example, 75.9 percent of the variations in the electric data are explained by the variations in labor force.

However, drawing conclusions from statistics must be tempered by common sense. The terms in a regression equation involve a constant that is the theoretical value of the dependent variable that shows no variable dependence, plus one or more independent variables multiplied by a coefficient that measures the dependence on that variable. The electric equation above states that, for the data period, each person on the labor force is responsible for the consumption of 4.16 MBtu per month. The negative constant is questionable, however, since it implies a negative electricity consumption for a very low labor force.

2.4.3 RAAP Energy and Production Data

Analysis of RAAP energy data was done for the five fiscal years 1985 to 1989. Production for the five years of the four predominant quantities NC, AOP, NAC/SAC and NG is shown in Figure 2-27; percentages of the quantities for FY 89 are shown in Figure 2-28. Tabulations of the energy and production quantities are included in Appendix B.

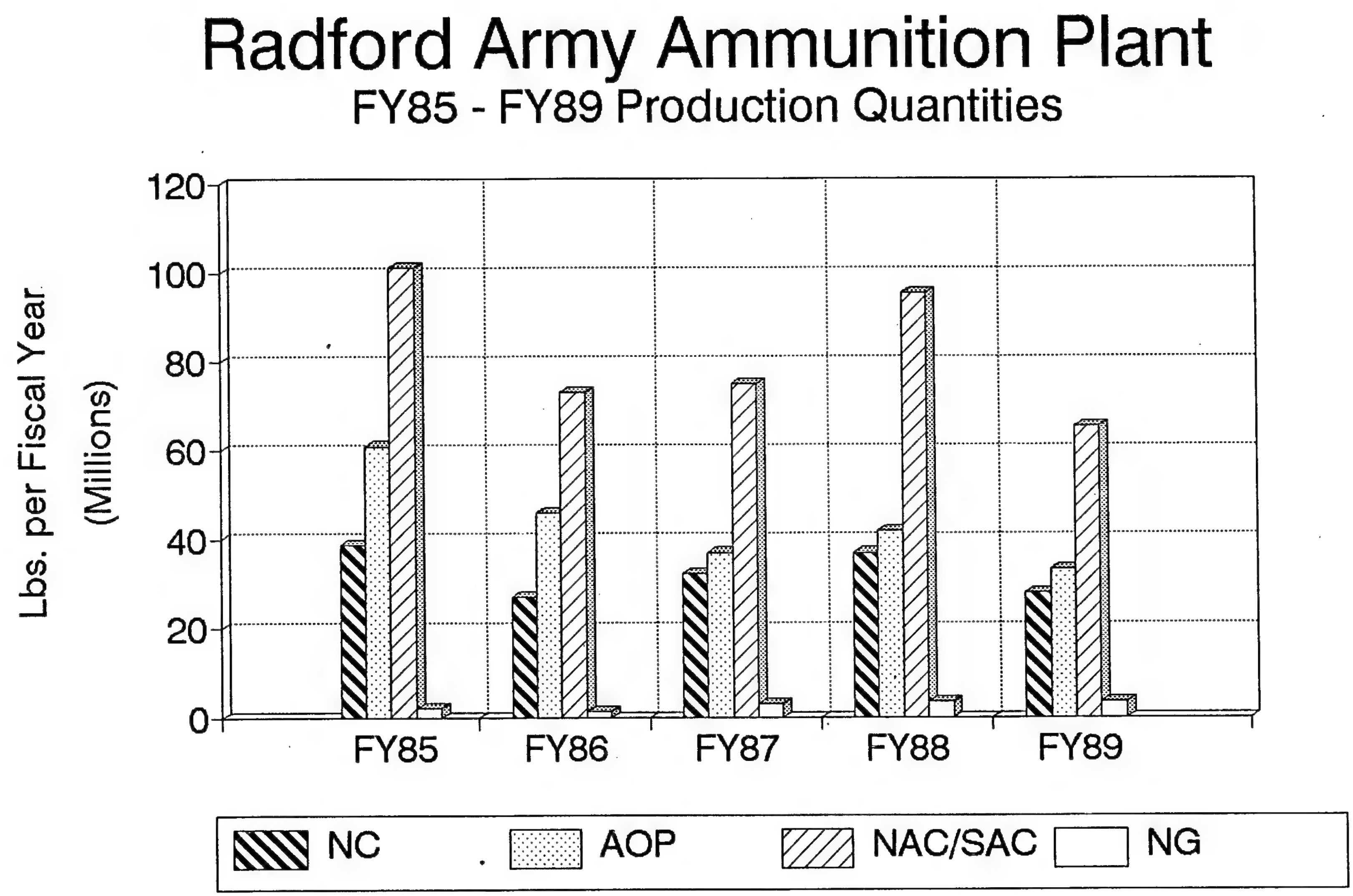

Radford Army Ammunition Plant
FY85 - FY89 Production Quantities
Lbs. per Fiscal Year
(Millions)
120
100
80
60
40
20
0
FY85
FY86
FY87
FY88
FY89
NC
AOP
NAC/SAC
NG

Figure 2-27

Radford Army Ammunition Plant

FY89 Production Quantities

Total = 129,941,696 lbs.

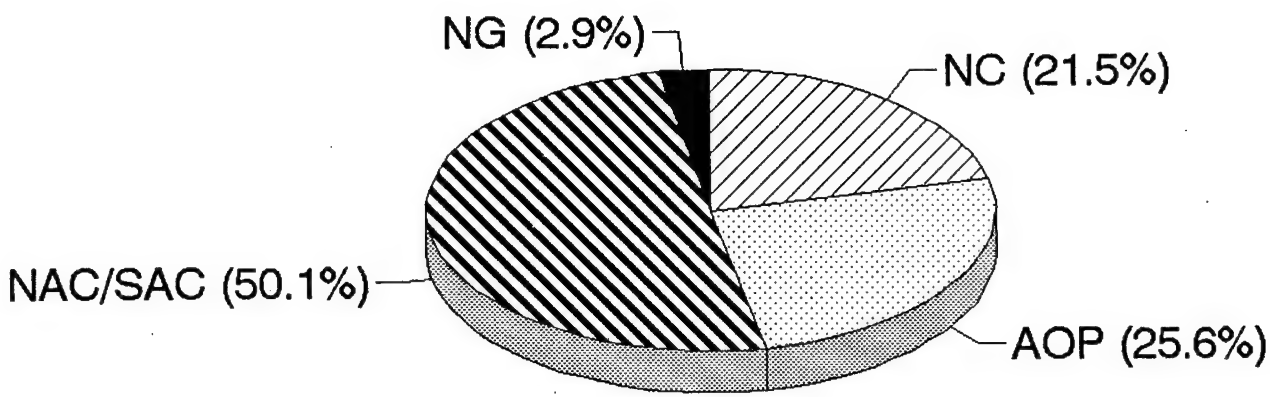


Figure 2-28

The dependencies of energy use were investigated with the aid of computer software. Correlation matrices were calculated using all dependent variables and independent variables. Once the highest correlations between variables were established, the correlated variables were plotted on a common x-axis and then analyzed for the most likely dependencies. Regression analyses were then done with each primary fuel as the dependent variable and production quantities and weather taken as independent variables.

Fuel oil and natural gas, the consumption of which are minor, were not included in the final analyses. Fuel oil is used as a boiler igniter and for destruction of waste propellants; no significant correlations with production or weather were found. Natural gas use represents such a minor part of fuel use that any correlations found would not be statistically significant.

The resulting monthly five-year energy consumption equations are:

Coal: $\text{MBtu} = 95{,}000 + 220\ \text{HDD} + 0.061\ \text{NC}$ (4)

$R^2\text{adj} = 0.802$

Elec: $\text{MBtu} = 26{,}880 + 0.00171\ (\text{AOP} + \text{NAC/SAC})$ (5)

$R^2\text{adj} = 0.603$

Where:

HDD = heating degree-days (base 65°F)

NC = nitrocellulose production (lbs)

AOP = ammonia oxidation production (lbs)

NAC/SAC = concentrated acid production (lbs)

R^2adj = R^2 adjusted for the number of variables and observations thereby providing an unbiased estimate

Figures 2-29 and 2-30 show the comparisons of the measured energy consumption to that calculated using the above equations.

RAAP FY85-89 Coal Use

MBtu = 95,000 + 220*HDD + 0.061*NC Lbs

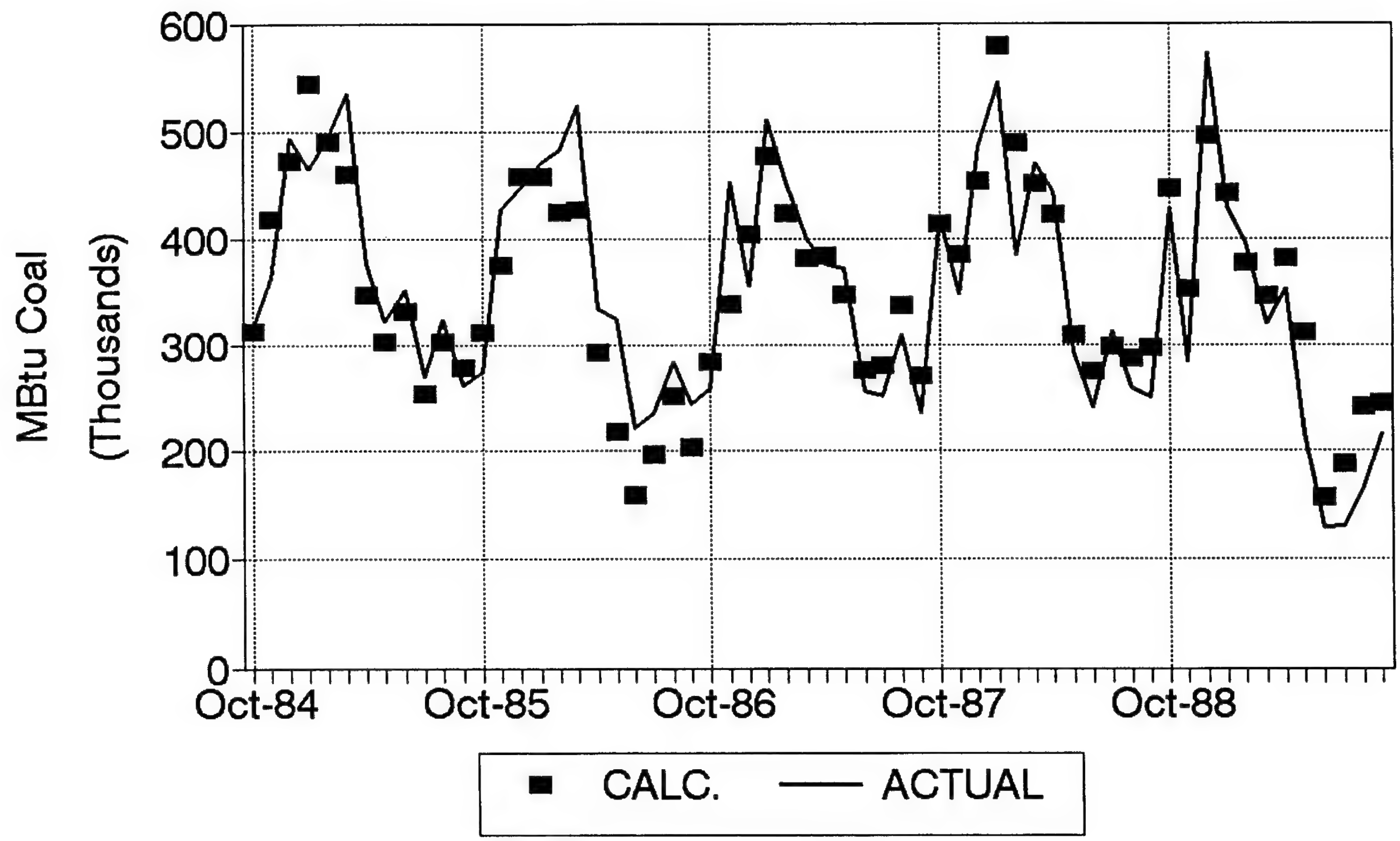


Figure 2-29

RAAP FY85-89 Electricity Use

MBtu = 26800 + 0.00171*Lbs(AOP+NAC/SAC)

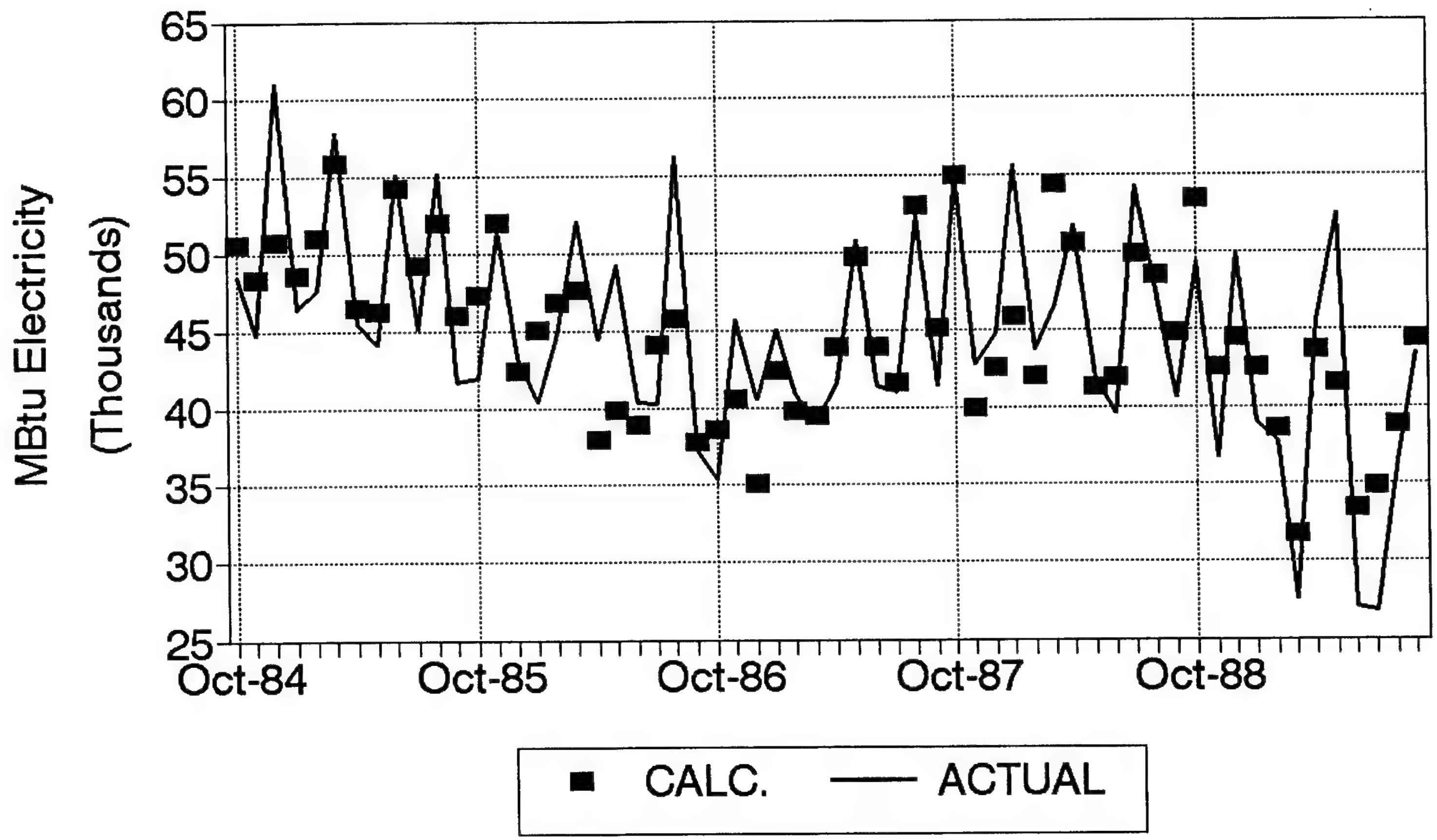


Figure 2-30

3/91

2.4.4 Discussion

2.4.4.1 Heating Fuels

The consumption of coal for the fiscal years 1985 to 1989 was most dependent on production variables, specifically that of NC. As with CERL, results indicate that consumption of coal also depends on weather (Figure 2-31). A somewhat stronger dependence on weather was calculated compared to the results of CERLs, shown by the MBtu/HDD coefficients of HDD in equations (2) and (4). CERL also found a higher constant monthly year-round coal consumption of 125,008 MBtu, compared to 94,388 MBtu reported here.

The total consumption of coal over the five-year period was approximately 21,172,000 MBtu; according to equation (4), approximately 5,505,000 MBtu, or 26 percent was due to weather; 9,955,300 MBtu, or 47 percent was related directly to production; and 5,711,700 MBtu, or 27 percent was not dependent on either (Figure 2-32).

2.4.4.2 Electricity

The strongest correlation found for electricity was with the ammonia oxidation process (AOP) and the acid-concentration processes (Figure 2-30). There is no significant correlation of electricity use with weather.

Total electricity use at RAAP during the five-year period was 2,687,500 MBtu; equation (5) shows that 1,074,800 MBtu (40 percent) was related to AOP and NAC/SAC production, while 1,612,700 MBtu (60 percent) represents a yearly constant use (Figure 2-33).

The total electricity used at RAAP comes from two sources, purchased from the local utility and generated on site with coal-fired steam (Figure 2-34). Since generated electricity is a byproduct of steam production, there is no significant correlation of either of the two components with an independent

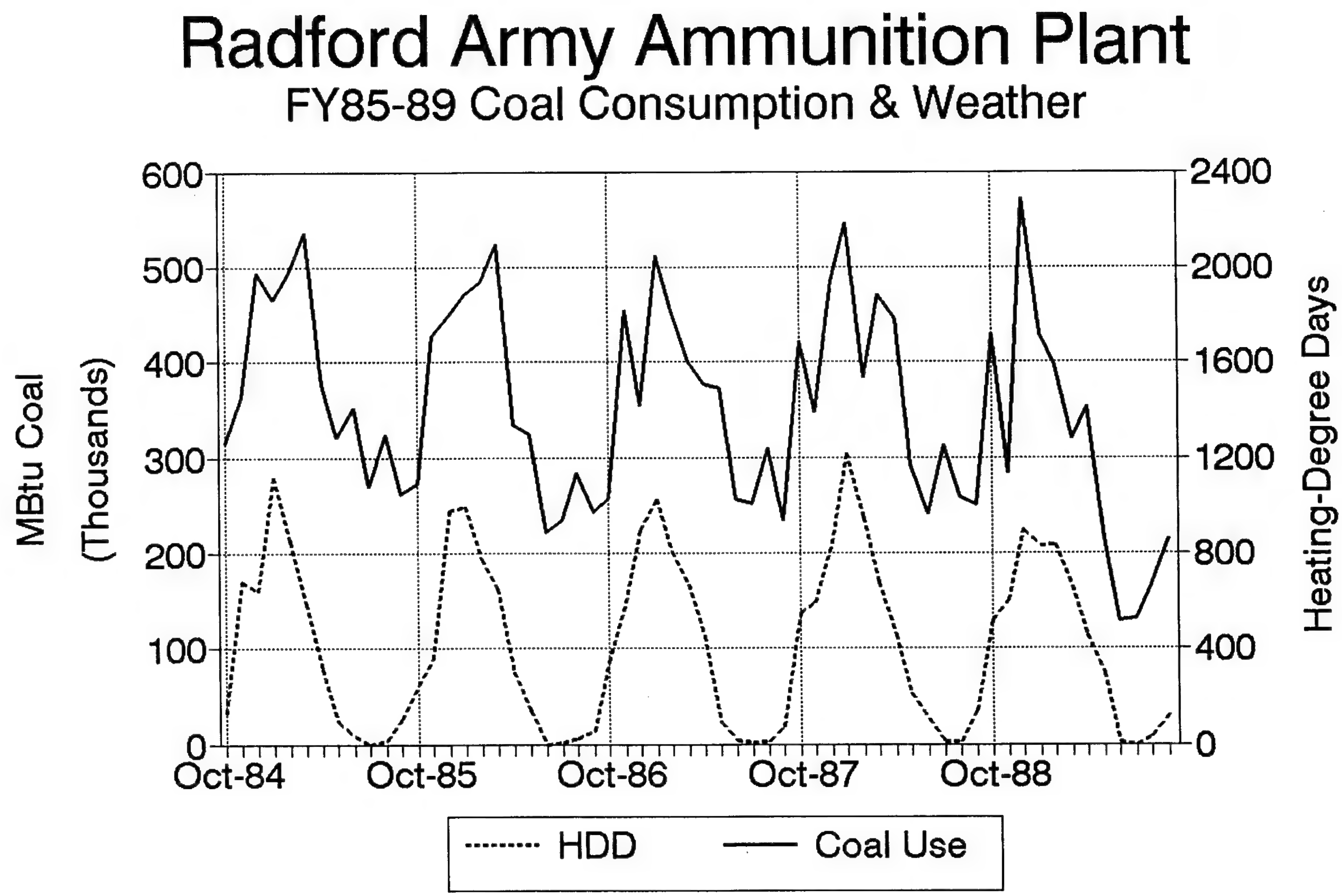

Radford Army Ammunition Plant
FY85-89 Coal Consumption & Weather
MBtu Coal (Thousands)
600
500
400
300
200
100
0
Heating-Degree Days
2400
2000
1600
1200
800
400
0
Oct-84
Oct-85
Oct-86
Oct-87
Oct-88
HDD
Coal Use

Figure 2-31

Radford Army Ammunition Plant

FY85-89 Coal Consumption Components

Total = 21,172,000 MBtu

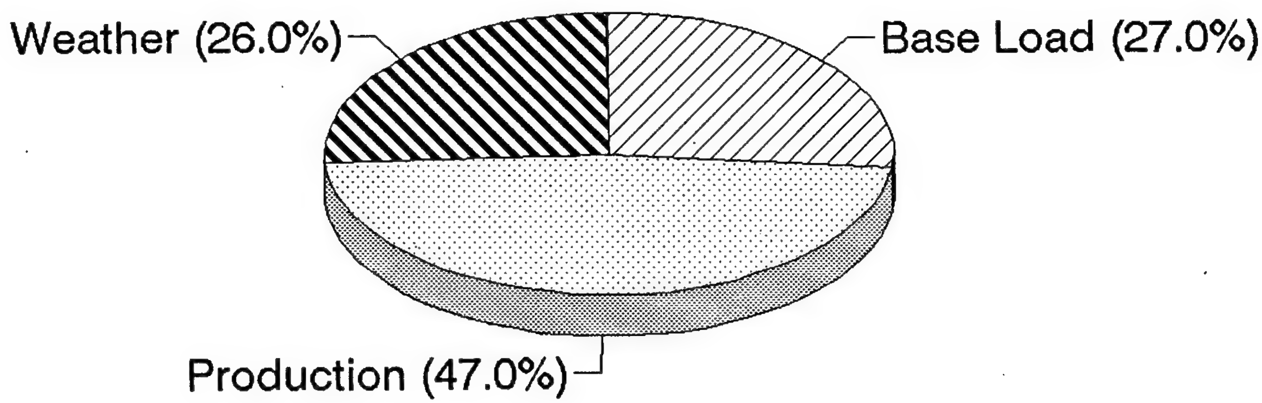


Figure 2-32

Radford Army Ammunition Plant

FY85-89 Elect. Consumption Components

Total = 2,687,500 MBtu

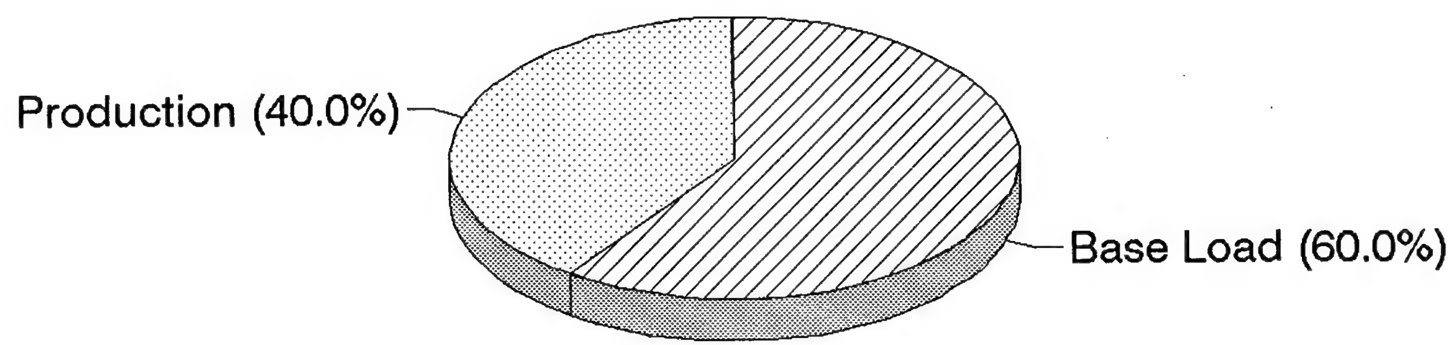


Figure 2-33

Radford Army Ammunition Plant

FY85-89 Electricity Consumption

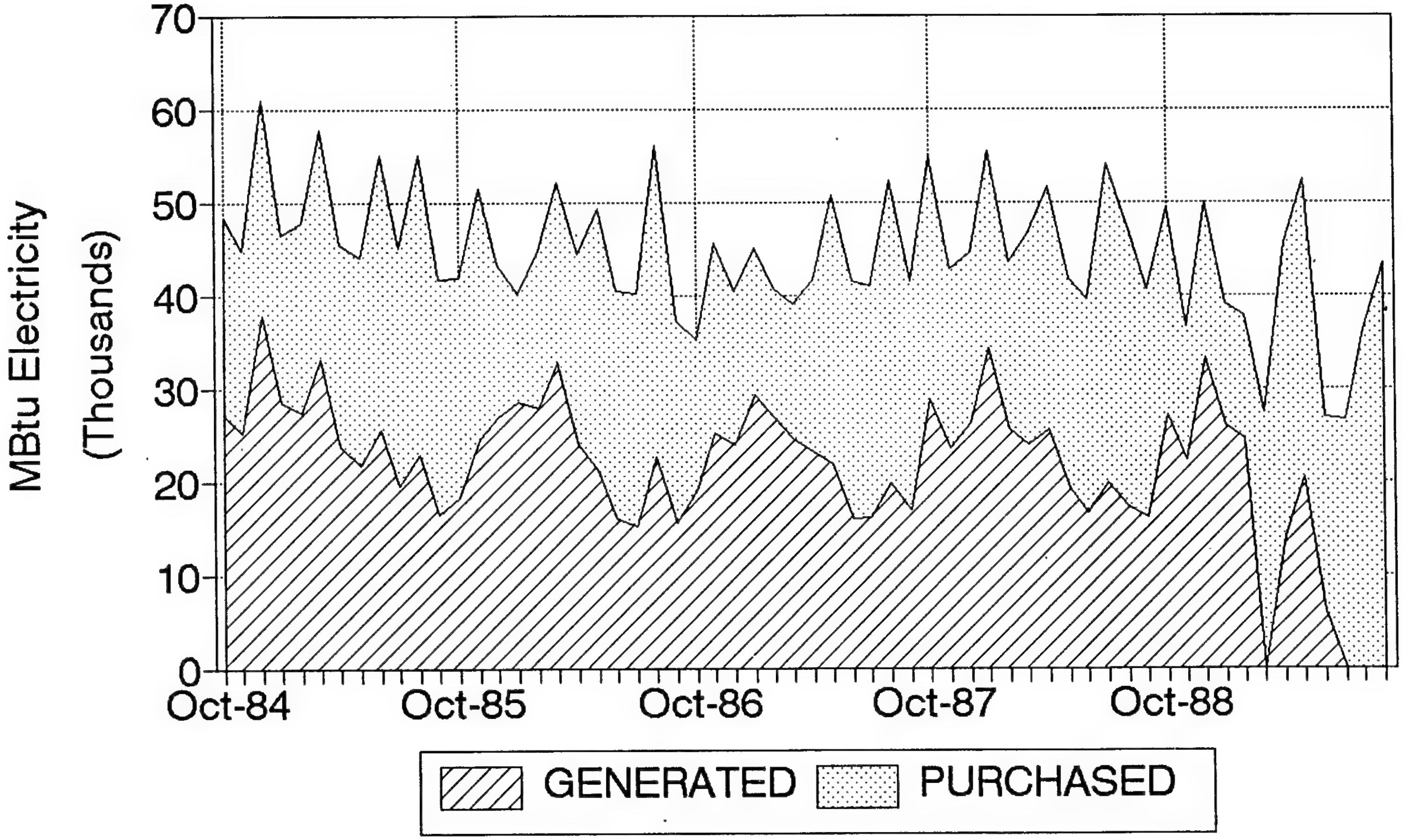


Figure 2-34

variable. There is, of course, correlation of coal use and generated electricity but neither of these quantities is an independent variable.

2.4.5 Summary

When summarized, significant energy use at RAAP can be divided into three components, each of which offer opportunities for savings. The three components are:

1. Production-related--over 40 percent of the variations in coal and electricity use at RAAP are directly related to changes in production. This is not a contradiction of the 86 percent process energy use fraction calculated in Section 2.3 using RAAP sub-metered data. Energy use was labelled process energy in Section 2.3 because it was used in production buildings. Therefore it included many uses that do not vary with production, such as, lighting and space heating.

2. Weather-related--over 26 percent of coal use is directly related to variances in cold weather. This is not surprising, since the use of building insulation is greatly restricted in an ammunition plant.

3. Constant energy use--the remainder of energy use, approximately 27 percent of coal and 60 percent of electricity, is more or less independent of any variations in weather or production. This represents such items as lighting and production standby heating and electrical requirements.

3.0 METHODOLOGY

3.1 Site Survey

Radford Army Ammunition Plant (RAAP) is a large industrial complex covering approximately 7,000 acres and containing more than 1,200 buildings. As discussed in Section 2.0, RAAP produces a wide variety of explosives and propellants. Because of the complexity of the RAAP site, it is impractical to survey each individual building. The intent of this effort is to survey those buildings that contain the more energy-intensive processes. A list of those areas and buildings are contained in Annex D of the Scope of Work (Appendix A).

Site surveys were conducted in November 1989, March 1990 and April 1990. As a result of information gathered, the areas surveyed have been modified to reflect inactive areas and more accurate naming conventions. These are listed below in alphabetical order.

Abbreviation	Description
AC	Acid
FN	Finishing
GL	Green Lines Solvent Propellant
GP	General plant, includes water, wastewater, compressed air, inert gas, incineration and power houses
MF	Multibase finishing (forced air dry)
NC	Nitrocellulose
NG	Nitroglycerin 1 and 2 and Premix 1 and 2
RK	Rocket, includes cast and extruded propellants, igniter line, and pilot "A"
RP	Rolled powder, 1st and 4th
SR	Solvent recovery

The emphasis for this study is to concentrate on energy savings in the industrial processes. A previous EEAP was performed that identified projects in building envelope, space heating systems, etc. This type of information was not gathered here unless the building is conditioned because of specific _process_ requirements. Survey sheets for each of the buildings visited plus personnel interview forms are contained in Volume III.

3.2 Energy Analysis

3.2.1 Linear Regression

The linear regression analysis was performed using a software package called Spreadsheet Regression (SSR), developed by Background Development Company of Tallahassee, Florida. SSR is a spreadsheet add-on program that can be run on most IBM® compatible personal computers. It is a complete multiple regression package, designed to operate entirely within a Lotus 1-2-3® spreadsheet.

3.2.2 ECOs

Energy savings for ECOs were calculated using standard methods documented in a variety of engineering texts including ASHRAE 1989 Fundamentals. Cost estimates were developed using 1989 Means or through equipment vendors' quotes.

All thermal energy savings are converted to MBtus of coal saved based on a heat balance analysis of the Powerhouse 1 turbine/generator system. For energy savings calculations, it was also assumed that all planned modifications (which are currently in progress) to Powerhouse 1 is complete. This means that Powerhouse 1 supplies steam to both the main plant and horseshoe areas. The fact that reduced steam production translates to less power production and increased power purchases is also taken into account. The details of these calculations are contained in Appendix B.

3.2.3 Economics

Economic evaluations were performed using the Life Cycle Cost in Design (LCCID) computer program available from the BLAST Support Office, Department of Mechanical and Industrial Engineering, University of Illinois at Urbana-Champaign. LCCID calculates life cycle costs, simple payback and SIR for use in evaluating energy conservation opportunities in DOD construction.

New energy discount factors have been published since the start of this study. Prior to submission of the projects for funding the Life Cycle Cost Analysis Summary sheets should be updated and the results reevaluated by the installation, using the most current energy prices and discount factors.

4.0 ENERGY ANALYSIS

4.1 Energy Conservation Opportunity (ECO) Assessment

Each of the ECOs listed in the Scope of Work plus others were reviewed for their applicability and potential for significant energy savings and cost effectiveness for buildings representative of high energy consumption production areas at RAAP. The buildings actually surveyed vary from the list in the scope of work, but the intent of the survey was accomplished--to survey and investigate energy savings in the major energy users in all active production areas. The results of this assessment are contained in tables in Appendix B.

For each of the ECOs that were chosen to be evaluated, energy savings were calculated, cost estimates made and life cycle cost analyses performed. A summary of the results are contained in Tables 4-1 and 4-2. The evaluated ECOs are described and listed alphabetically by process area in Table 4-1. Note that Net Cost Savings includes additional purchased electricity and all non-energy savings (costs). An alphabetical listing of evaluated ECOs along with a summary of the energy and cost savings analysis is shown in Table 4-2. Table 4-3 contains a listing prioritized by SIR. Table 4-4 contains a list prioritized by simple payback. Backup data and calculations are contained in Appendix B.

The ECO numbers are of the form XX-X-# where X represents a letter and # represents a number. The first two letters are an abbreviation of the plant area where the ECO applies (refer to page III-1). The next letter designates the ECO category. The various ECO categories are listed on the Preliminary Evaluation of ECOs located in Volume II, Appendix B. The remaining number is the sequential number of an ECO in a particular area and category.

Table 4-1. ECOs Evaluated - Titles

#	ECO #	Description
1	FN-U-1	Cover water dry tank surface with insulating spheres
2	FN-U-2	Insulate fiberglass water dry tanks
3	GP-B-1	Install energy efficient motors
4	GP-B-2	Install energy efficient motors - upon failure
5	GP-B-3	Install energy efficient motors instead of rewind
6	GP-B-4	Install variable frequency drives on plant water pumps
7	GP-D-1	Replace existing IGG with heat recovery type
8	GP-D-2	Install condensing heat exchanger at Power House #1
9	GP-N-1	Replace incandescents with 35W HPS screw-ins
10	GP-N-2	Replace incandescents with Circline fluorescents
11	GP-N-3	Replace exterior incandescents with fluorescents
12	GP-N-4	Replace 40W fluorescents with 34W
13	GP-N-5	Replace lamps and ballasts with energy efficient types
14	GP-N-6	Replace incandescents with HPS fixtures
15	GP-N-7	Replace inefficient ballasts
16	GP-N-8	Replace incandescents with color-corrected HPS screw-ins
17	GP-N-9	Replace 40W fluorescents with 34W upon failure
18	GP-N-10	Replace inefficient ballasts upon failure
19	GP-W-1	Install vinyl strip door curtains
20	GP-X-1	Reduce exhaust gas temperature in incinerator
21	GP-X-2	Reduce water flow into incinerator
22	GP-X-3	Reduce incinerator excess air
23	GP-X-4	Install turning vanes in boiler ductwork
24	GP-X-5	Install thermostat control system in motor houses
25	GP-X-6	Change incinerator fuel to natural gas
26	MF-X-1	Install preheat coil controls in FADs
27	NC-U-1	Insulate boiling and poacher tubs
28	NC-X-1	Modify boiling tub heating method
29	SR-I-1	Remove steam coils in Activated Carbon Area

Table 4-2. ECO Evaluations - Results

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	FN-U-1	$52,643		0	12,258	0	0	$9,427	5.31	2.07
2	FN-U-2	$45,905		0	2,822	0	0	$2,170	20.12	0.75
3	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
4	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--
5	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--
6	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
7	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
8	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
10	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
11	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
12	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
13	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
14	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
15	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
16	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
17	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
18	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
19	GP-W-1	$19,251		0	16,055	0	0	$12,348	1.48	3.00
20	GP-X-1	***		0	0	18,308	0	$78,175	***	***
21	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
22	GP-X-3	***		0	0	18,572	0	$79,300	***	***
23	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
24	GP-X-5	$42,488		0	4,602	0	0	$3,540	11.42	1.33
25	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
26	MF-X-1	$64,219		0	706	0	0	$933	65.50	0.16
27	NC-U-1	$70,271		0	6,674	0	0	$5,133	13.02	0.84
28	NC-X-1	$122,374		0	123,431	0	0	$94,927	1.23	8.97
29	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 4-3. Results Of ECO Evaluations - Prioritized By SIR

#	ECO #	Construction Cost Plus SIOH	Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	GP-X-3	***	0	0	18,572	0	$79,300	***	***
2	GP-X-1	***	0	0	18,308	0	$78,175	***	***
3	GP-X-2	$14,830	0	0	3,942	0	$16,832	0.84	20.36
4	NC-X-1	$122,374	0	123,431	0	0	$94,927	1.23	8.97
5	SR-I-1	$17,932	1,576	0	0	0	$13,979	1.22	7.20
6	GP-X-4	$40,512	2,480	0	0	0	$21,998	1.67	6.83
7	GP-N-3	$22,667	1,024	0	0	0	$15,770	1.37	6.52
8	GP-X-6	$263,750	0	0	86,217	(86,217)	$78,457	3.20	4.80
9	GP-N-1	$132,467	4,003	0	0	0	$65,833	1.91	4.67
10	GP-B-4	$195,266	10,940	0	0	0	$96,994	1.91	4.59
11	GP-N-2	$13,766	371	0	0	0	$6,416	2.04	4.38
12	GP-D-2	$1,529,750	-695	215,204	0	0	$340,000	4.28	3.13
13	GP-W-1	$19,251	0	16,055	0	0	$12,348	1.48	3.00
14	FN-U-1	$52,643	0	12,258	0	0	$9,427	5.31	2.07
15	GP-N-8	$155,150	2,354	0	0	0	$31,081	4.80	1.87
16	GP-D-1	$289,627	0	24,475	0	0	$39,876	6.91	1.45
17	GP-X-5	$42,488	0	4,602	0	0	$3,540	11.42	1.33
18	GP-N-6	$533 **	2	0	0	0	$44	11.40	1.01
19	NC-U-1	$70,271	0	6,674	0	0	$5,133	13.02	0.84
20	GP-B-1	$1,737,092	12,827	0	0	0	$113,724	14.53	0.78
21	FN-U-2	$45,905	0	2,822	0	0	$2,170	20.12	0.75
22	GP-N-5	$87 **	0.58	0	0	0	$5	16.16	0.70
23	GP-N-7	$59 **	0.39	0	0	0	$4	16.30	0.69
24	GP-N-4	$8 **	0.13	0	0	0	$1	7.38	0.35
25	MF-X-1	$64,219	0	706	0	0	$933	65.50	0.16
26	GP-N-9	$1 *	0.13	0	0	0	$1	0.70	--
27	GP-N-10	$7 *	0.28	0	0	0	$2	2.70	--
28	GP-B-3	$580-$13,293 *	10-171	0	0	0	$85-$1513	5.2-9.0	--
29	GP-B-2	$369-$7,596 *	10-177	0	0	0	$85-$1600	2.9-5.8	--

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 4-4. Results Of ECO Evaluations - Prioritized By Simple Payback

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	GP-X-3	***		0	0	18,572	0	$79,300	***	***
2	GP-X-1	***		0	0	18,308	0	$78,175	***	***
3	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
4	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20
5	NC-X-1	$122,374		0	123,431	0	0	$94,927	1.23	8.97
6	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
7	GP-W-1	$19,251		0	16,055	0	0	$12,348	1.48	3.00
8	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
10	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
11	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
12	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
13	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
14	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
15	FN-U-1	$52,643		0	12,258	0	0	$9,427	5.31	2.07
16	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
17	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
18	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
19	GP-X-5	$42,488		0	4,602	0	0	$3,540	11.42	1.33
20	NC-U-1	$70,271		0	6,674	0	0	$5,133	13.02	0.84
21	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
22	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
23	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
24	FN-U-2	$45,905		0	2,822	0	0	$2,170	20.12	0.75
25	MF-X-1	$64,219		0	706	0	0	$933	65.50	0.16
26	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
27	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
28	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--
29	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

ECO Number: FN-U-1

COVER THE WATER DRY TANKS WITH HOLLOW PLASTIC SPHERES

Description

The water dry process is used to remove residual ether and alcohol left in the propellant after the solvent recovery process. Open tanks filled with water heated to 149F are used to purge the solvents from the propellant. These tanks are about nine feet high and have a diameter of 16 feet. Approximately 730 MBtu per year of heat is lost from the surface of each water dry tank. Over 86 percent of these losses is due to evaporation and the remainder is conduction.

The surface heat loss can be significantly reduced by adding a layer of two-inch hollow plastic spheres. These spheres would reduce the exposed surface area (the driving force for evaporation) by 85 percent and also improve the U-value of the surface by a factor of two.

Recommendations

Based on the Life Cycle Cost Analysis, it is recommended that two-inch hollow plastic spheres be used on the surface of the water dry tanks.

Construction Cost	=	$49,899
Annual Energy Savings (coal)	=	12,258 MBtu
Annual Energy Cost Savings	=	$19,735
Electricity Price Differential Costs	=	$10,308
Net Cost Savings	=	$ 9,427
SIR	=	2.07
Simple Payback	=	5.31 years

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: FNU1
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: FN-U-1 COVER WATER DRY TANK WITH PLASTIC BALLS
FISCAL YEAR 1990 DISCRETE PORTION NAME: FLOATING SPHERES
ANALYSIS DATE: 02-21-91 ECONOMIC LIFE 15 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	49899.
B. SIOH	$	2744.
C. DESIGN COST	$	2994.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	50073.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	50073.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	8.78	0.
B. DIST	$ 4.27	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ 1.61	12258.	$ 19735.	10.01	197551.
F. TOTAL		12258.	$ 19735.		$ 197551.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ -10308.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ -93906.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ -93906.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 65192.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 9427.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 103645.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 2.07
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 5.31

ECO Number: FN-U-2

INSULATE THE FIBERGLASS WATER DRY TANKS

Description

There are 15 active water dry buildings at RAAP. Each building has two water dry tanks that are nine feet with a 16-foot diameter. Seven of the buildings have had the original wooden tanks replaced by new fiberglass tanks. Approximately, 2,419 MBtu/year of heat is lost by conduction heat transfer from the sides of these fiberglass tanks.

By installing two inches of fiberglass wrap insulation and a metal jacket to seal it, the conduction heat transfer losses can be reduced by approximately 88 percent.

Recommendations

Based on the Life Cycle Cost Analysis (see results below), this ECO is not recommended.

Construction Cost	=	$43,512
Annual Energy Savings (coal)	=	2,822 MBtu
Annual Energy Cost Savings	=	$4,543
Electricity Price Differential Costs	=	$2,373
Net Cost Savings	=	$2,170
SIR	=	0.55
Simple Payback	=	20.12 years

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: FNU2
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: FN-U-2 INSULATE FIBERGLASS WATER DRY TANKS
FISCAL YEAR 1990 DISCRETE PORTION NAME: EXTERIOR INSULATION
ANALYSIS DATE: 02-21-91 ECONOMIC LIFE 25 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	43512.
B. SIOH	$	2393.
C. DESIGN COST	$	2611.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	43664.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	43664.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	11.37	0.
B. DIST	$ 4.27	0.	$ 0.	17.06	0.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ .00	0.	$ 0.	17.52	0.
E. COAL	$ 1.61	2822.	$ 4543.	13.34	60609.
F. TOTAL		2822.	$ 4543.		$ 60609.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ -2373.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ -27645.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ -27645.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 20001.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 2170.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 32964.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .75
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 20.12

Table 4-2. ECO Evaluations - Results

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	FN-U-1	$52,643		0	14,421	0	0	$23,454	2.14	4.68
2	FN-U-2	$45,905		0	3,320	0	0	$5,399	8.09	1.24
3	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
4	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--
5	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--
6	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
7	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
8	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
10	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
11	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
12	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
13	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
14	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
15	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
16	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
17	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
18	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
19	GP-W-1	$19,251		0	18,888	0	0	$30,719	0.60	16.78
20	GP-X-1	***		0	0	18,308	0	$78,175	***	***
21	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
22	GP-X-3	***		0	0	18,572	0	$79,300	***	***
23	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
24	GP-X-5	$42,488		0	5,414	0	0	$8,806	4.59	2.18
25	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
26	MF-X-1	$64,219		0	833	0	0	$1,892	32.28	0.30
27	NC-U-1	$70,271		0	6,674	0	0	$10,873	6.15	1.63
28	NC-X-1	$122,374		0	140,261	0	0	$229,625	0.51	19.72
29	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20
	TOTALS	$4,830,655		34,884	429,490	127,039	(86,217)	$1,309,261	--	--

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 4-3. Results Of ECO Evaluations - Prioritized By SIR

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	GP-X-1	***		0	0	18,308	0	$78,175	***	***
2	GP-X-3	***		0	0	18,572	0	$79,300	***	***
3	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
4	NC-X-1	$122,374		0	140,261	0	0	$229,625	0.51	19.72
5	GP-W-1	$19,251		0	18,888	0	0	$30,719	0.60	16.78
6	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20
7	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
8	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
9	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
10	FN-U-1	$52,643		0	14,421	0	0	$23,454	2.14	4.68
11	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
12	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
13	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
14	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
15	GP-X-5	$42,488		0	5,414	0	0	$8,806	4.59	2.18
16	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
17	NC-U-1	$70,271		0	6,674	0	0	$10,873	6.15	1.63
18	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
19	FN-U-2	$45,905		0	3,320	0	0	$5,399	8.09	1.24
20	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
21	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
22	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
23	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
24	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
25	MF-X-1	$64,219		0	833	0	0	$1,892	32.28	0.30
26	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--
27	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--
28	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
29	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
	TOTALS	$4,830,655		34,884	429,490	127,039	(86,217)	$1,309,261	--	--

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 4-4. Results Of ECO Evaluations - Prioritized By Simple Payback

#	ECO #	Construction Cost Plus SIOH		Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR
1	GP-X-1	***		0	0	18,308	0	$78,175	***	***
2	GP-X-3	***		0	0	18,572	0	$79,300	***	***
3	NC-X-1	$122,374		0	140,261	0	0	$229,625	0.51	19.72
4	GP-W-1	$19,251		0	18,888	0	0	$30,719	0.60	16.78
5	GP-X-2	$14,830		0	0	3,942	0	$16,832	0.84	20.36
6	SR-I-1	$17,932		1,576	0	0	0	$13,979	1.22	7.20
7	GP-N-3	$22,667		1,024	0	0	0	$15,770	1.37	6.52
8	GP-X-4	$40,512		2,480	0	0	0	$21,998	1.67	6.83
9	GP-N-1	$132,467		4,003	0	0	0	$65,833	1.91	4.67
10	GP-B-4	$195,266		10,940	0	0	0	$96,994	1.91	4.59
11	GP-N-2	$13,766		371	0	0	0	$6,416	2.04	4.38
12	FN-U-1	$52,643		0	14,421	0	0	$23,454	2.14	4.68
13	GP-X-6	$263,750		0	0	86,217	(86,217)	$78,457	3.20	4.80
14	GP-D-2	$1,529,750		-695	215,204	0	0	$340,000	4.28	3.13
15	GP-X-5	$42,488		0	5,414	0	0	$8,806	4.59	2.18
16	GP-N-8	$155,150		2,354	0	0	0	$31,081	4.80	1.87
17	NC-U-1	$70,271		0	6,674	0	0	$10,873	6.15	1.63
18	GP-D-1	$289,627		0	24,475	0	0	$39,876	6.91	1.45
19	GP-N-4	$8	**	0.13	0	0	0	$1	7.38	0.35
20	FN-U-2	$45,905		0	3,320	0	0	$5,399	8.09	1.24
21	GP-N-6	$533	**	2	0	0	0	$44	11.40	1.01
22	GP-B-1	$1,737,092		12,827	0	0	0	$113,724	14.53	0.78
23	GP-N-5	$87	**	0.58	0	0	0	$5	16.16	0.70
24	GP-N-7	$59	**	0.39	0	0	0	$4	16.30	0.69
25	MF-X-1	$64,219		0	833	0	0	$1,892	32.28	0.30
26	GP-B-2	$369-$7,596	*	10-177	0	0	0	$85-$1600	2.9-5.8	--
27	GP-B-3	$580-$13,293	*	10-171	0	0	0	$85-$1513	5.2-9.0	--
28	GP-N-9	$1	*	0.13	0	0	0	$1	0.70	--
29	GP-N-10	$7	*	0.28	0	0	0	$2	2.70	--
	TOTALS	$4,830,655		34,884	429,490	127,039	(86,217)	$1,309,261	--	--

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

ECO Number: FN-U-1

COVER THE WATER DRY TANKS WITH HOLLOW PLASTIC SPHERES

Description

The water dry process is used to remove residual ether and alcohol left in the propellant after the solvent recovery process. Open tanks filled with water heated to 149F are used to purge the solvents from the propellant. These tanks are about nine feet high and have a diameter of 16 feet. Approximately 730 MBtu per year of heat is lost from the surface of each water dry tank. Over 86 percent of these losses is due to evaporation and the remainder is conduction.

The surface heat loss can be significantly reduced by adding a layer of two-inch hollow plastic spheres. These spheres would reduce the exposed surface area (the driving force for evaporation) by 85 percent and also improve the U-value of the surface by a factor of two.

Recommendations

Based on the Life Cycle Cost Analysis, it is recommended that two-inch hollow plastic spheres be used on the surface of the water dry tanks.

Construction Cost	=	$49,899
Annual Energy Savings (coal)	=	14,421 MBtu
Annual Energy Cost Savings	=	$23,218
Additional Purchased Electricity	=	$ 9,143
Reduced Power House O&M	=	$9,379
Net Cost Savings	=	$23,454
SIR	=	4.68
Simple Payback	=	2.14 years

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: BALLS
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: FN-U-1 COVER WATER DRY TANK WITH PLASTIC BALLS
FISCAL YEAR 1990 DISCRETE PORTION NAME: WATER DRY TANKS
ANALYSIS DATE: 10-02-90 ECONOMIC LIFE 15 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	49899.
B. SIOH	$	2745.
C. DESIGN COST	$	2994.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	50074.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	50074.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	8.78	0.
B. DIST	$ 4.27	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ 1.61	14421.	$ 23218.	10.01	232410.
F. TOTAL		14421.	$ 23218.		$ 232410.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 236.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 2150.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 2150.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 76695.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 23454.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 234560.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 4.68
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 2.14

ECO Number: FN-U-2

INSULATE THE FIBERGLASS WATER DRY TANKS

Description

There are 15 active water dry buildings at RAAP. Each building has two water dry tanks that are nine feet with a 16-foot diameter. Seven of the buildings have had the original wooden tanks replaced by new fiberglass tanks. Approximately, 2,419 MBtu/year of heat is lost by conduction heat transfer from the sides of these fiberglass tanks.

By installing two inches of fiberglass wrap insulation and a metal jacket to seal it, the conduction heat transfer losses can be reduced by approximately 88 percent.

Recommendations

Based on the Life Cycle Cost Analysis (see results below), this ECO is recommended.

Construction Cost	=	\$43,512
Annual Energy Savings (coal)	=	3,320 MBtu
Annual Energy Cost Savings	=	\$5,346
Additional Purchased Electricity	=	\$2,105
Reduced Power House O&M	=	\$2,159
Net Cost Savings	=	\$5,400
SIR	=	1.24
Simple Payback	=	8.09 years

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: INSTANKS
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: FN-U-2 INSULATE FIBERGLASS WATER DRY TANKS
FISCAL YEAR 1990 DISCRETE PORTION NAME: 14 WATER DRY TANKS
ANALYSIS DATE: 10-02-90 ECONOMIC LIFE 15 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	43512.
B. SIOH	$	2394.
C. DESIGN COST	$	2611.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	43665.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	43665.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	8.78	0.
B. DIST	$ 4.27	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ 1.61	3320.	$ 5345.	10.01	53505.
F. TOTAL		3320.	$ 5345.		$ 53505.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 54.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 492.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 492.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 17657.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 5399.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 53997.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.24
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 8.09

ECO Number: GP-B-1

REPLACE EXISTING MOTORS WITH ENERGY-EFFICIENT MOTORS

Discussion

Electric motors consume a large portion of the total electricity at RAAP, with over 6,000 motors ranging from 1 hp to 800 hp. Most of these motors are not high-efficiency type, and an improvement in efficiency of just a few percent could save thousands of dollars in energy and demand charges over the life of the motor.

This ECO evaluates replacing operating standard-duty motors with energy-efficient motors. Motors ranging in size from 10 hp to 150 hp which operate at least 24 hrs/day, 5 days/week, were analyzed.

Recommendations

Based on the Life Cycle Cost Analysis, it is not recommended that standard-duty motors be removed and replaced with energy-efficient motors due to an SIR < 1.

Construction Cost	=	$1,646,533
Energy Savings (electricity)	=	12,827 MBtu/year
Cost Savings	=	$113,724/year
SIR	=	0.78
Simple Payback	=	14.5 years

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPB1
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-B-1 REPLACE MOTORS W/ ENERGY EFF. MOTORS
FISCAL YEAR 1990 DISCRETE PORTION NAME: HP10-150
ANALYSIS DATE: 10-05-90 ECONOMIC LIFE 25 YEARS PREPARED BY: T. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	1646533.
B. SIOH	$	90560.
C. DESIGN COST	$	98792.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	1652297.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	1652297.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	12827.	$ 113724.	11.37	1293044.
B. DIST	$ .00	0.	$ 0.	17.06	0.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ .00	0.	$ 0.	17.52	0.
E. COAL	$ .00	0.	$ 0.	13.34	0.
F. TOTAL		12827.	$ 113724.		$ 1293044.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 426705.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 113724.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 1293044.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .78
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 14.53

ECO Number: GP-B-2

INSTALL ENERGY-EFFICIENT MOTORS--UPON FAILURE

Discussion

Electric motors consume a large portion of the total electricity at RAAP, with over 6,000 motors ranging from 1 hp to 800 hp. Most of these motors are not high-efficiency type, and an improvement in efficiency of just a few percent could save thousands of dollars in energy and demand charges over the life of the motor.

This ECO evaluates the policy change such that when new motors are purchased, either because additional capacity is needed or upon failure of an old motor, require that the new motors be energy efficient. In virtually all instances, it is economical to incur the additional cost of the energy-efficient motor over the standard-duty motor since it will pay for itself many times over.

Recommendations

It is recommended for three-shifts-per-day operation that energy-efficient motors 3 hp and greater be purchased upon failure of old motors or when new motors are needed. For two-shift operation, it is cost-effective to purchase new energy efficient motors in the sizes ranging from 15 hp to 125 hp. The additional capital investment is worth it over the life of the motor in terms of energy savings.

On a Per-Motor Basis (Continuous Operation)

Incremental Cost	=	\$350-\$7,200
Annual Savings (Electricity)	=	10-177 MBtu/yr
Annual Cost Savings	=	\$85-\$1,600/yr
Payback	=	2.9-5.8 years

ECO Number: GP-B-3

INSTALL ENERGY-EFFICIENT MOTORS RATHER THAN REWIND EXISTING MOTORS

Discussion

Electric motors consume a large portion of the total electricity at RAAP, with over 6,000 motors ranging from 1 hp to 800 hp. Most of these motors are not high-efficiency type, and an improvement in efficiency of just a few percent could save thousands of dollars in energy and demand charges over the life of the motor.

This ECO evaluates the policy changes such that when motors are sent out to be rewound, efficiency testing is required. Contracts with rewind companies should include requirements for use of core loss testers and verification of manufacturer's original specifications, as a minimum.

An additional policy change is that instead of rewinding failed motors, replace them with new energy-efficient motors. The policy now is to purchase a new motor if the cost of rewinding is greater than 50 to 60 percent of the cost to replace it. In some cases, it may be cost effective to replace rather than rewind even when this criteria is not met, especially for motors which are operated for two to three shifts per day.

Recommendation

It is recommended that motors from 3 hp to 150 hp which are operated two or three shifts per day be evaluated on a case-by-case basis for replacement with new energy-efficient motors rather than being rewound. Paybacks are generally much shorter than the life of the motor. For those motors which do not qualify for replacement, it is recommended that rewind contracts include efficiency testing by core loss testers and verification of manufacturer's original specifications.

On a Per-Motor Basis (Continuous Operation)

Incremental Cost	=	\$550-\$12,600
Annual Savings (Electricity)	=	10-171 MBtu/yr
Annual Cost Savings	=	\$85-\$1,513/yr
Payback	=	5.2-9.0 years

ECO #GP-B-4

INSTALL VARIABLE FREQUENCY DRIVES IN MAIN PLANT WATER SUPPLY PUMPS

Discussion

Currently, about 24,000,000 gallons per day of water is pumped from the New River to the Filter Plant, Building 409. The main plant uses about 12,000,000 gallons per day; the remainder is allowed to flow back to the New River. If a variable frequency drive was installed on the water supply pumps in Building 409, together with controls to maintain a storage level in Building 409, no excess water would be pumped and energy could be saved.

Recommendations

Based on a Life Cycle Cost Analysis, this ECO is recommended. The results of the analysis are listed below.

Construction Cost	=	$185,086
Annual Energy Savings (Electricity)	=	10,340 MBtu
Annual Cost Savings	=	$96,994
Simple Payback	=	1.91 years
SIR	=	4.59

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPB4
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-B-4 INSTALL VARIABLE SPEED DRIVES
FISCAL YEAR 1990 DISCRETE PORTION NAME: VSPS
ANALYSIS DATE: 06-14-90 ECONOMIC LIFE 15 YEARS PREPARED BY: P. HUTCHINS

1. INVESTMENT

A. CONSTRUCTION COST	$	185086.
B. SIOH	$	10180.
C. DESIGN COST	$	11106.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	185735.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	185735.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	10940.	$ 96994.	8.78	851608.
B. DIST	$ .00	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ .00	0.	$ 0.	10.01	0.
F. TOTAL		10940.	$ 96994.		$ 851608.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 281031.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 96994.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 851608.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 4.59
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 1.91

ECO Number: GP-D-1

REPLACE INERT GAS GENERATORS

Description

The existing Inert Gas Generators (IGGs) waste all of the heat liberated by the natural gas they burn. That wasted energy could be used to generate 40 psi steam for general use. The savings would result from reduced coal use at the No. 1 Power House.

The existing IGGs cannot be economically modified to include steam generating surface. New IGGs with steam generation capability should replace the existing IGGs and the recovered 40-psig steam piped into the existing steam distribution system (see the diagrams on the following page).

Recommendation

The Life Cycle Cost Analysis below indicates a favorable SIR for this ECO. However, RAAP-Hercules Engineering has determined that the most appropriate system that should replace the existing facilities is a Pressure Swing Adsorption type. A request for funding has previously been submitted. Therefore, this ECO will not be recommended.

Construction Cost	=	$274,528
Annual Energy Savings (coal)	=	24,475 MBtu
Annual Energy Cost Savings	=	$39,405
Additional Purchased Electricity	=	$18,256
Reduced Power House O&M	=	$18,727
Net Cost Savings	=	$39,876
SIR	=	1.45
Simple Payback	=	6.91 years

3/91

LIFE CYCLE COST ANALYSIS SUMMARY — STUDY: IGREPLAC
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) — LCCID 1.035

INSTALLATION & LOCATION: RADFORD AAP — REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-D-1 REPLACE INERT GAS SYSTEM
FISCAL YEAR 1990 DISCRETE PORTION NAME: INERT GAS GENERATOR
ANALYSIS DATE: 09-27-90 ECONOMIC LIFE 15 YEARS PREPARED BY: G. FALLON

1. INVESTMENT

A. CONSTRUCTION COST	$	274528.
B. SIOH	$	15099.
C. DESIGN COST	$	16472.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	275489.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	275489.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	8.78	0.
B. DIST	$ 4.27	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ 1.61	24475.	$ 39405.	10.01	394442.
F. TOTAL		24475.	$ 39405.		$ 394442.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 471.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 4291.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 4291.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 130166.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 39876.

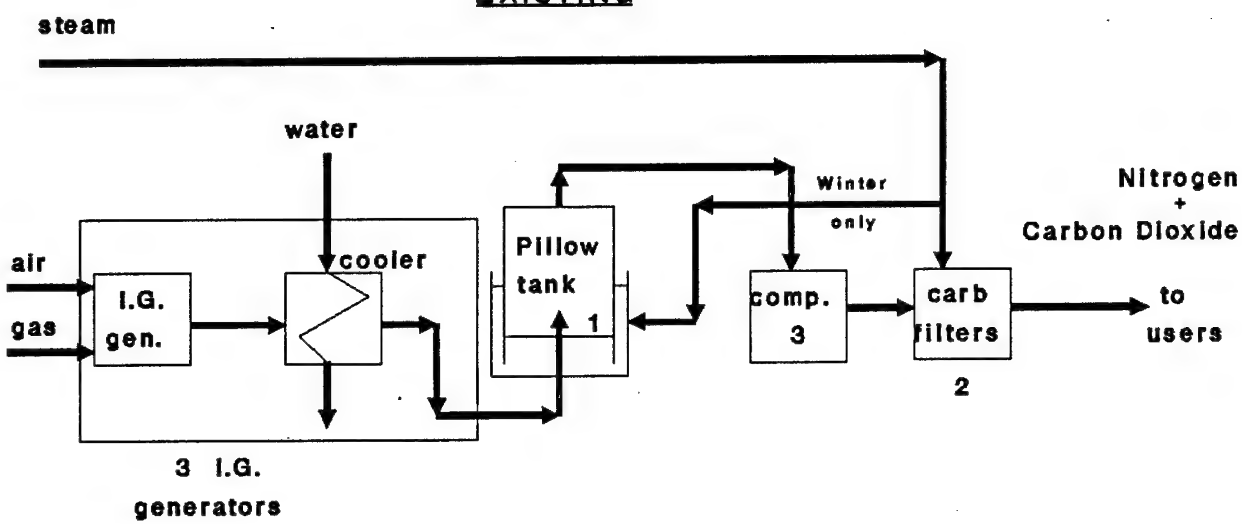
5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 398732.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.45
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 6.91

Radford Army Ammunition Plant
Inert Gas Generator

EXISTING



NEW

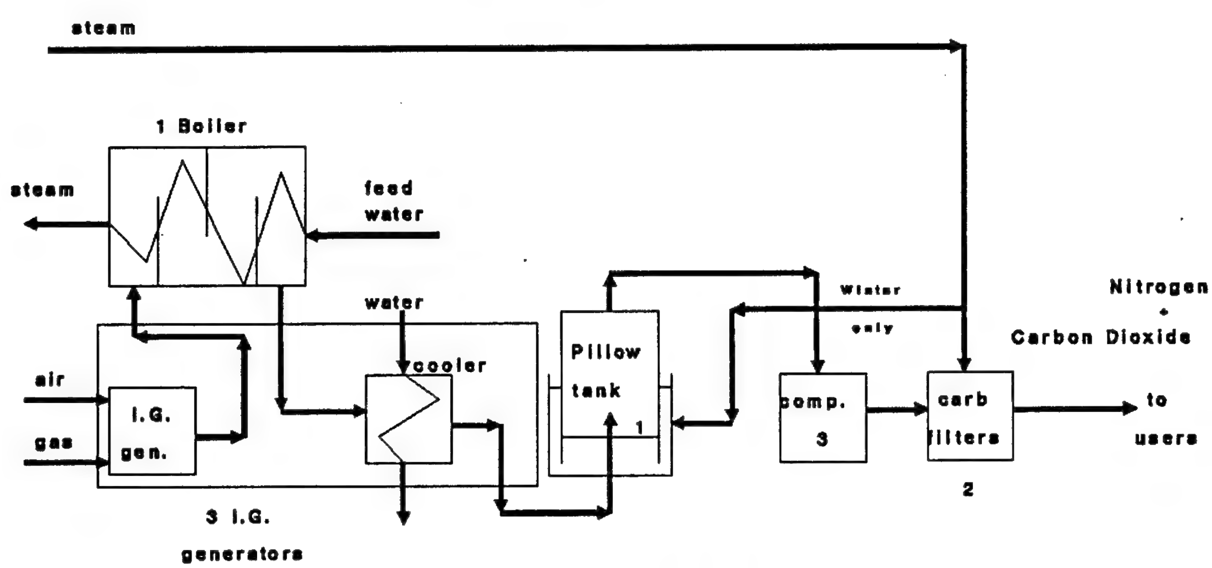


FIGURE 4-1

ECO Number GP-D-2

INSTALL CONDENSING HEAT EXCHANGER IN POWER HOUSE 1

Discussion

The largest single source of boiler heat loss is in the exit gases. The higher the exit gas (stack) temperature, the higher the heat loss. The existing stack temperature at Power House 1 is about 350°F. By reducing the stack temperature to 100°F, substantial energy can be recovered.

Condensing Heat Exchanger Corporation (CH_x) proposes to reduce the stack temperature by absorbing the heat into the make-up water through a teflon-coated gas-to-liquid heat exchanger.

Recommendations

This project is not recommended because the technology is not sufficiently demonstrated on coal firing.

Construction Cost	=	$1,450,000
Energy Savings (Coal)	=	215,204 MBtu/yr
Additional Energy Requirements (Electricity)	=	695 MBtu/yr
Net Cost Savings	=	$340,000
Payback	=	4.3 years
SIR	=	3.1

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPD2
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-D-2 INSTALL CONDENSING HEAT EXCHANGER
FISCAL YEAR 1990 DISCRETE PORTION NAME: HEAT EXCHANGER
ANALYSIS DATE: 10-22-90 ECONOMIC LIFE 25 YEARS PREPARED BY: FALLON

1. INVESTMENT

A. CONSTRUCTION COST	$	1450000.
B. SIOH	$	79750.
C. DESIGN COST	$	87000.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	1455075.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	1455075.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	-695.	$ -6165.	11.37	-70092.
B. DIST	$ 4.27	0.	$ 0.	17.06	0.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ 3.36	0.	$ 0.	17.52	0.
E. COAL	$ 1.61	215204.	$ 346478.	13.34	4622023.
F. TOTAL		214509.	$ 340314.		$ 4551931.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 1502137.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 340314.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 4551931.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 3.13
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 4.28

ECO Number: GP-N-1

REPLACE INCANDESCENTS--EXPLOSION PROOF

Discussion

Many buildings at RAAP are lit by inefficient incandescent lighting for interior and exterior areas. This ECO evaluates replacement of the incandescent lamps in explosion-proof fixtures with 35 watt high pressure sodium (HPS) units, which consist of HPS lamps and ballasts with a medium base adapter which screws into the incandescent socket. These lamps produce a yellowish light which should be suitable for all exterior and many interior applications (see ECO #GP-N-8 for color-corrected HPS retrofits).

Recommendations

Based on the Life Cycle Cost Analysis, it is recommended that 35 W HPS screw-in retrofits be installed in the incandescent explosion-proof fixtures throughout RAAP where yellowish light is acceptable.

Construction Cost	=	$125,561
Energy Savings (electricity)	=	4,003 MBtu/yr
Cost Savings	=	$65,833/yr
SIR	=	4.67
Simple Payback	=	1.9 years

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPN1
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-N-1 REPLACE INCAND. W/ 35W HPS SCREW-INS
FISCAL YEAR 1990 DISCRETE PORTION NAME: TOTAL
ANALYSIS DATE: 06-14-90 ECONOMIC LIFE 15 YEARS PREPARED BY: T. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	125561.
B. SIOH	$	6906.
C. DESIGN COST	$	7534.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	126001.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	126001.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	4003.	$ 35487.	8.78	311579.
B. DIST	$ .00	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ .00	0.	$ 0.	10.01	0.
F. TOTAL		4003.	$ 35487.		$ 311579.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 30346.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 276452.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 276452.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 102821.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= 3.29
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 65833.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 588031.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 4.67
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 1.91

ECO Number: GP-N-2

REPLACE INCANDESCENTS WITH CIRCLINE FLUORESCENTS

Discussion

Many buildings at RAAP are lit with inefficient incandescent lighting. This ECO analyzes the replacement of interior incandescent lamps with 32 W circline fluorescent screw-in retrofit fixtures. This type of project is suitable for nonexplosion-proof interior fixtures. Replacing 100 W incandescents with 32 W circlines would increase the lumen output by five percent, from 1,750 lumens to 1,830 lumens. Replacing 150 W incandescents with 32 W circlines would decrease the lumen output 57 percent, from 2,880 lumens to 1,830 lumens.

Recommendations

Based on the Life Cycle Cost Analysis, it is recommended that incandescent lamps be replaced with fluorescent circline fixtures.

Construction Cost	=	$13,048
Annual Energy Savings (electricity)	=	371 MBtu/yr
Annual Cost Savings	=	$6,416/yr
SIR	=	4.38
Simple Payback	=	2.0 years

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPN2
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-N-2 REPLACE INCAND. W/ CIRCLINE FLUOR.
FISCAL YEAR 1990 DISCRETE PORTION NAME: TOTAL
ANALYSIS DATE: 10-05-90 ECONOMIC LIFE 15 YEARS PREPARED BY: T. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	13048.
B. SIOH	$	718.
C. DESIGN COST	$	783.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	13094.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	13094.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	371.	$ 3285.	8.78	28845.
B. DIST	$ .00	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ .00	0.	$ 0.	10.01	0.
F. TOTAL		371.	$ 3285.		$ 28845.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 3131.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 28523.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 28523.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 9519.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= 2.93
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 6416.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 57368.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 4.38
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 2.04

ECO Number: GP-N-3

REPLACE EXTERIOR INCANDESCENTS WITH COMPACT FLUORESCENT FLOODS

Discussion

Many buildings at RAAP are lit with inefficient incandescent lighting. This ECO analyzes the replacement of exterior incandescent floods with 13 W PL compact fluorescent flood retrofits which screw into the incandescent sockets. This type of project is suitable for nonexplosion-proof fixtures. Lumen level is reduced 25 percent when 10W W floods are replaced, from 1,190 lumens to 900 lumens, with a 53 percent lumen reduction for replacement of 150 W floods (1,900 to 900 lumens).

Recommendations

Based on the Life Cycle Cost Analysis, it is recommended that incandescent floods be replaced with fluorescent floods.

Construction Cost	=	$21,485
Annual Energy Savings (electricity)	=	1,024 MBtu/yr
Annual Cost Savings	=	$15,770/yr
SIR	=	6.52
Simple Payback	=	1.4 years

LIFE CYCLE COST ANALYSIS SUMMARY　　STUDY: GPN3
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)　　LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP　　REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-N-3　REPLACE INCAND. W/ FLUOR. FLOODS
FISCAL YEAR 1990　DISCRETE PORTION NAME: TOTAL
ANALYSIS DATE: 10-05-90　ECONOMIC LIFE 15 YEARS PREPARED BY: T. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	21485.
B. SIOH	$	1182.
C. DESIGN COST	$	1289.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	21560.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	21560.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	1024.	$ 9082.	8.78	79737.
B. DIST	$ .00	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ .00	0.	$ 0.	10.01	0.
F. TOTAL		1024.	$ 9082.		$ 79737.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)　　$ 6688.
(1) DISCOUNT FACTOR (TABLE A)　　9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1)　　$ 60928.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 60928.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33)　　$ 26313.
A IF 3D1 IS = OR > 3C　GO TO ITEM 4
B IF 3D1 IS < 3C　CALC　SIR = (2F5+3D1)/1F)=　4.92
C IF 3D1B IS = > 1　GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 15770.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C)　　$ 140664.

6. DISCOUNTED SAVINGS RATIO　　(SIR)=(5 / 1F)=　6.52
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED)　SPB=1F/4　　1.37

ECO Number: GP-N-4

GROUP RELAMPING OF FLUORESCENTS

Discussion

The existing four-foot fluorescent fixtures are equipped with standard efficiency 40 W lamps. Relamping all fixtures with 34 W efficient lamps is evaluated. Lumen level is reduced 13 percent from 2,770 lumens to 2,420 lumens per lamp.

Recommendations

It is not recommended that all 40 W lamps be replaced with 34 W lamps as a group relamping project due to an SIR < 1 and the relatively long payback. However, it is recommended that as lamps fail, they be replaced with 34 W lamps. See ECO #GP-N-9.

Construction Cost	=	$7.45/lamp
Electricity Savings	=	0.13 MBtu/lamp
Cost Savings	=	$1.13/year
Payback	=	7.4 years
SIR	=	0.35

LIFE CYCLE COST ANALYSIS SUMMARY   STUDY: GPN4
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)   LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP   REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-N-4   GROUP RELAMPING OF FLUORESCENTS
FISCAL YEAR 1990   DISCRETE PORTION NAME: UNIT
ANALYSIS DATE: 10-05-90 ECONOMIC LIFE 3 YEARS PREPARED BY: T. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	7.
B. SIOH	$	1.
C. DESIGN COST	$	1.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	9.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	9.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 1.	2.56	3.
B. DIST	$ .00	0.	$ 0.	2.90	0.
C. RESID	$ .00	0.	$ 0.	2.75	0.
D. NAT G	$ .00	0.	$ 0.	2.76	0.
E. COAL	$ .00	0.	$ 0.	2.70	0.
F. TOTAL		0.	$ 1.		$ 3.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 2.62
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 1.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 1.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 3.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .35
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 7.38

ECO Number: GP-N-5

GROUP RELAMPING AND BALLAST REPLACEMENT FOR FLUORESCENTS

Discussion

The existing four-foot fluorescent fixtures are equipped with standard efficiency ballasts and 40 W lamps. ECO Number GP-N-4 addresses lamp replacement only and ECO Number GP-N-7 addresses ballasts only, but this project evaluates the replacement of both simultaneously. With Watt-Miser ballasts and Watt-Miser Plus lamps, the lumen level for two-lamp fixtures will be reduced 11 percent from 5,540 lumens to 4,930 lumens.

Recommendations

It is not recommended that all fluorescent fixtures be retrofitted with ballasts and lamps due to an SIR <1 and a long payback period. However, it is recommended that as lamps and ballasts fail, they be replaced with energy-efficient types (see ECOs #GP-N-9 and GP-N-10).

Construction Cost	=	$82.31/fixture
Electricity Savings	=	0.58 MBtu/fixture
Cost Savings	=	$5.10/year
Payback	=	16.2 years
SIR	=	0.70

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPN5
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-N-5 FLUOR. GROUP RELAMPING & BALLAST REPLAC.
FISCAL YEAR 1990 DISCRETE PORTION NAME: UNIT
ANALYSIS DATE: 10-05-90 ECONOMIC LIFE 25 YEARS PREPARED BY: T. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	82.
B. SIOH	$	5.
C. DESIGN COST	$	5.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	83.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	83.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	1.	$ 5.	11.37	58.
B. DIST	$ .00	0.	$ 0.	17.06	0.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ .00	0.	$ 0.	17.52	0.
E. COAL	$ .00	0.	$ 0.	13.34	0.
F. TOTAL		1.	$ 5.		$ 58.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 19.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 5.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 58.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .70
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 16.16

ECO Number GP-N-6

REPLACE INCANDESCENTS WITH HPS FIXTURES--EXPLOSION PROOF

Discussion

Incandescent lighting, an inefficient source of light, is used extensively throughout RAAP. Replacement of the existing explosion-proof incandescent fixtures with explosion-proof high pressure sodium (HPS) fixtures is evaluated. The 35 W HPS lamp produces equivalent lumens as a 150 W incandescent but the yellowish colored light may not be acceptable in all locations. The installation of a 50 W HPS color-corrected lamp, which provides a white-colored light and a higher lumen level, was investigated instead.

Recommendations

It is not recommended that the incandescent fixtures be replaced with 50 W HPS explosion-proof fixtures due to the high payback.

Construction Cost	=	$505/fixture
Electricity Savings	=	2.39 MBtu/fixture
Cost Savings	=	$44.46/year
Payback	=	11.4 years
SIR	=	1.01

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPN6
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-N-6 REPLACE INCAND. W/ HPS EXPL-PRF FIXTURES
FISCAL YEAR 1990 DISCRETE PORTION NAME: UNIT
ANALYSIS DATE: 10-05-90 ECONOMIC LIFE 25 YEARS PREPARED BY: T. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	505.
B. SIOH	$	28.
C. DESIGN COST	$	31.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	508.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	508.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	2.	$ 21.	11.37	241.
B. DIST	$ .00	0.	$ 0.	17.06	0.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ .00	0.	$ 0.	17.52	0.
E. COAL	$ .00	0.	$ 0.	13.34	0.
F. TOTAL		2.	$ 21.		$ 241.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 23.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 271.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 271.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 80.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= .63
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 44.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 512.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.01
(IF < 1 PROJECT DOES NOT QUALIFY)
**** Project does not qualify for ECIP funding; 4,5,6 for information only.

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 11.42

ECO Number: GP-N-7

REPLACE INEFFICIENT FLUORESCENT BALLASTS

Discussion

The existing four-foot fluorescent fixtures are generally equipped with standard efficiency ballasts. Replacement of standard two-lamp ballasts with Watt-Miser two-lamp ballasts is evaluated. Light levels should not be reduced significantly by this measure, even when 34 W lamps are used with the retrofit ballasts.

Recommendations

It is not recommended that standard efficiency ballasts be replaced with energy-efficient ballasts as a group retrofit project due to a SIR <1 and a long payback period. However, it is recommended that upon failure of existing ballasts, they be replaced with high-efficiency Watt-Miser type ballasts (see ECO #GP-N-10).

Construction Cost	=	$56.34/ballast
Electricity Savings	=	0.39 MBtu/ballast
Cost Savings	=	$3.45/year
Payback	=	16.3 years
SIR	=	0.69

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPN7
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-N-7 REPLACE FLUOR. BALLASTS W/ ENERGY-EFF.
FISCAL YEAR 1990 DISCRETE PORTION NAME: UNIT
ANALYSIS DATE: 10-05-90 ECONOMIC LIFE 25 YEARS PREPARED BY: T. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	56.
B. SIOH	$	3.
C. DESIGN COST	$	4.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	57.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	57.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 3.	11.37	39.
B. DIST	$ .00	0.	$ 0.	17.06	0.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ .00	0.	$ 0.	17.52	0.
E. COAL	$ .00	0.	$ 0.	13.34	0.
F. TOTAL		0.	$ 3.		$ 39.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 13.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 3.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 39.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .69
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 16.49

ECO Number: GP-N-8

REPLACE INCANDESCENTS WITH COLOR-CORRECTED HPS SCREW-INS FOR EXPLOSION-PROOF FIXTURES

Discussion

Many buildings at RAAP are lit by inefficient incandescent lighting for interior areas. This ECO evaluates replacement of the incandescent lamps in explosion-proof fixtures with 50 watt color-corrected HPS units, which consist of HPS lamps and ballasts with a medium base adapter which screws into the incandescent socket. These lamps have been color-corrected to produce a whitish light rather than a yellowish light usually associated with HPS. At the present time, these lamps are only produced in this wattage (50 W). Light levels will be decreased 33 percent when 200 W incandescents (3,710 lumens) are replaced by 50 W color-corrected HPS (2,500 lumens). When 150 W incandescents are replaced by 50 W color-corrected HPS, light levels will decrease 13 percent, from 2,880 lumens to 2,500 lumens.

Recommendations

Based on the Life Cycle Cost Analysis, it is recommended that 50 W HPS screw-in retrofits be installed in the interior incandescent explosion-proof fixtures.

Construction Cost	=	$147,062
Energy Savings (electricity)	=	2,354 MBtu/yr
Cost Savings	=	$31,081/yr
SIR	=	1.87
Simple Payback	=	4.8 years

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPN8
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-N-8 REPLACE INCAND. W/ COLOR-CORRECT HPS
FISCAL YEAR 1990 DISCRETE PORTION NAME: TOTAL
ANALYSIS DATE: 10-05-90 ECONOMIC LIFE 15 YEARS PREPARED BY: T. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	147062.
B. SIOH	$	8089.
C. DESIGN COST	$	8824.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	147578.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	147578.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	2354.	$ 20868.	8.78	183218.
B. DIST	$ .00	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ .00	0.	$ 0.	10.01	0.
F. TOTAL		2354.	$ 20868.		$ 183218.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 10213.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 93040.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 93040.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 60462.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= 1.65
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 31081.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 276258.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.87
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 4.75

ECO Number: GP-N-9

REPLACE 40 W FLUORESCENTS WITH 34 W FLUORESCENTS UPON FAILURE

Discussion

The four-foot fluorescent fixtures at RAAP use 40 W lamps. This ECO evaluates the policy change that all 40 W fluorescents be replaced with 34 W energy-efficient fluorescent lamps upon failure. The cost for this measure would only be the incremental material cost. Lumen level is reduced 13 percent from 2,770 lumens to 2,420 lumens per lamp.

Recommendations

It is recommended that 34 W lamps replace the 40 W lamps upon failure.

On a Per-Lamp Basis

Incremental Cost	=	$0.75
Annual Energy Savings (electricity)	=	0.13 MBtu/yr
Annual Cost Savings	=	$1.13/yr
Simple Payback	=	0.7 years

ECO Number: GP-N-10

REPLACE BALLASTS WITH ENERGY-EFFICIENT TYPE UPON FAILURE

Discussion

The four-foot fluorescent fixtures at RAAP use standard efficiency ballasts. This ECO evaluates the policy change that all standard efficiency ballasts be replaced with energy-efficient ballasts upon failure. The cost for this measure would only be the incremental material cost.

Recommendations

It is recommended that energy-efficient ballasts be installed as the existing ballasts fail.

On a Per-Fixture Basis

Incremental Cost	=	\$6.67
Annual Energy Savings (electricity)	=	0.28 MBtu/yr
Annual Cost Savings	=	\$2.45/yr
Simple Payback	=	2.7 years

ECO Number: GP-W-1

INSTALL CLEAR VINYL STRIP CURTAINS ON 25 BUILDINGS

Discussion

There are many buildings in the plant area that operate during the winter with open doors and bays. These openings impose excessive infiltration loads on the building's heating systems and impair the ability to maintain the specified operating temperatures. Installation of clear vinyl strip curtains can reduce the infiltration rate and save the additional steam energy used to offset these heat losses. During the site survey, 25 buildings were identified as potential candidates for utilization of vinyl strip curtains. A list of these buildings is contained in the calculations section for this ECO in the Appendix.

Recommendations

Based on the possible safety hazard from static electricity buildup, clear vinyl strip curtains should not be installed.

Construction Cost	=	$18,247
Coal Energy Savings	=	16,055 MBtu/year
Coal Cost Savings	=	$25,849/year
Electricity Price Differential Costs	=	$13,501/year
Net Cost Savings	=	$12,348/year
Payback	=	1.48 years
SIR	=	3.00

3/91

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPW1
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-W-1 INSTALL VINYL STRIP CURTAINS
FISCAL YEAR 1990 DISCRETE PORTION NAME: STRIP CURTAINS
ANALYSIS DATE: 02-04-91 ECONOMIC LIFE 5 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	18247.
B. SIOH	$	1004.
C. DESIGN COST	$	1095.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	18311.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	18311.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	3.95	0.
B. DIST	$ 4.27	0.	$ 0.	4.65	0.
C. RESID	$ .00	0.	$ 0.	4.34	0.
D. NAT G	$ 3.36	0.	$ 0.	4.47	0.
E. COAL	$ 1.61	16055.	$ 25849.	4.27	110373.
F. TOTAL		16055.	$ 25849.		$ 110373.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ -13501.
(1) DISCOUNT FACTOR (TABLE A) 4.10
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ -55354.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ -55354.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 36423.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 12348.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 55019.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 3.00
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 1.48

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: VINLSTRP
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-W-1 INSTALL VINYL STRIP CURTAINS
FISCAL YEAR 1990 DISCRETE PORTION NAME: 25 BUILDINGS
ANALYSIS DATE: 09-26-90 ECONOMIC LIFE 15 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	18247.
B. SIOH	$	1004.
C. DESIGN COST	$	1095.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	18311.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	18311.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	8.78	0.
B. DIST	$ 4.27	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ 1.61	18888.	$ 30410.	10.01	304401.
F. TOTAL		18888.	$ 30410.		$ 304401.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 309.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 2815.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 2815.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 100452.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 30719.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 307216.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 16.78
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 .60

ECO Number: GP-X-1

REDUCE INCINERATOR EXIT GAS TEMPERATURE

Description

The two waste propellant incinerators currently operate at approximately 1400°F at the exit of the rotating kiln. Operating at this high exist gas temperature (EGT) generates excessive nitrogen oxides (NO_x), wastes energy, and reduces equipment life. The waste propellant does not require this high EGT to be safely incinerated since it will ignite and burn at a temperature below 500°F. Energy savings, reduced air pollution, and reduced maintenance costs can all be achieved by reducing the EGT to a more reasonable level. The ideal EGT is the lowest temperature that safely incinerates all of the waste propellant. To achieve this new lower temperature, the control set-point could be simply re-set to control a lower temperature. The new lower temperature should be carefully selected to assure operational safety.

It is recognized that the existing environmental permits for the incinerators state an EGT that is rigidly adhered to by the operating personnel. The permit can be revised to reflect the new, lower EGT. The state EPA is likely to be sympathetic to this idea since lower air pollution will result from operating at the lower temperature.

Recommendation

Based on the Life Cycle Cost Analysis, it is recommended that the exit gas temperature of the two incinerators shall be reduced from 1400°F to 1000°F. The pertinent figures concerning this ECO are listed below.

Construction Cost	=	*
Annual Energy Savings (fuel oil #2)	=	18,308 MBtu

Annual Cost Savings (fuel oil #2)	=	$78,175
SIR	=	--
Simple Payback	=	--

*There are no construction costs because only a simple adjustment of a temperature controller by the operator is required. However, there may be some costs incurred for repermitting.

ECO Number: GP-X-2

REDUCE INCINERATOR WATER FLOW

Description

Each incinerator currently evaporates the propellant transport water while incinerating the waste propellant. The water evaporation accounts for the high energy costs of operating the incinerator. If, therefore, the quantity of water evaporated could be safely reduced, the energy costs would also be reduced.

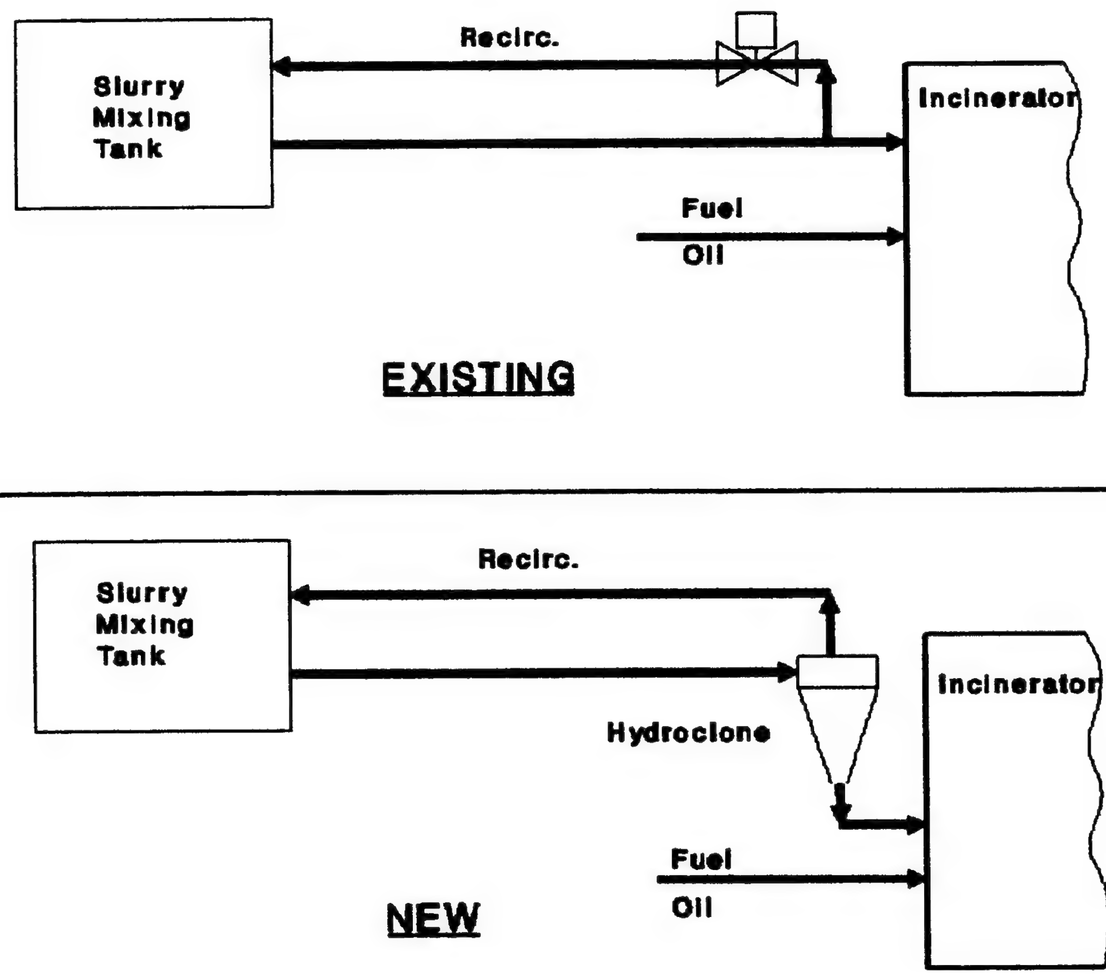
The installation of a hydroclone (hydraulic cyclone separator) at the propellant inlet to the incinerator would concentrate the propellant immediately before entering the incinerator. The hydroclone separates some of the solid propellant particles from the water centrifugally. The heavier particles tend to collect in the bottom of the hydroclone while the lighter ones pass through and would be returned to the mixing tank. The result would be a reduced water flow into the incinerator, and reduced energy costs. This would also result in reduced air pollution from the incinerators (lower fuel flow, therefore lower pollution flow).

Recommendation

Based on the Life Cycle Cost Analysis, it is recommended that two hydroclones should be installed, one for each of the incinerators, including new recirculation lines (see sketch on following page). The pertinent figures concerning this ECO are listed below.

Construction Cost	=	$14,057
Annual Energy Savings (fuel oil #2)	=	3,942 MBtu
Annual Energy Cost Savings (fuel oil #2)	=	$16,832
SIR	=	20.36
Simple Payback	=	0.84 years

Radford Army Ammunition Plant
Incinerator Hydroclone



LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPX2
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-X-2 REDUCE INCINERATOR WATER FLOW
FISCAL YEAR 1990 DISCRETE PORTION NAME: INSTALL HYDROCLONE
ANALYSIS DATE: 10-05-90 ECONOMIC LIFE 25 YEARS PREPARED BY: G. FALLON

1. INVESTMENT

A. CONSTRUCTION COST	$	14057.
B. SIOH	$	774.
C. DESIGN COST	$	844.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	14108.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	14108.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	11.37	0.
B. DIST	$ 4.27	3942.	$ 16832.	17.06	285849.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ .00	0.	$ 0.	17.52	0.
E. COAL	$ 1.61	0.	$ 0.	13.34	0.
F. TOTAL		3942.	$ 16832.		$ 285849.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 94330.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 16832.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 285849.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 20.36
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 .84

ECO Number: GP-X-3

REDUCE INCINERATOR EXHAUST GAS OXYGEN CONCENTRATION

Description

Existing stack test data show the dry exhaust O_2 concentration to be 15 percent. This is much too high. It wastes fuel, increases air pollution through increased NO_x production and increased particulate matter emissions by overloading the scrubber. The proper O_2 stack concentration should be in the range of two to three percent for #2 oil-fired burners.

Recommendation

Based on the Life Cycle Cost Analysis, it is recommended that the exhaust gas O_2 concentration for both incinerators be reduced from 15 percent to two percent. This can be accomplished by readjusting the air/fuel controls and adjusting the burners. The results of the analysis are shown below.

Construction Cost	=	*
Annual Energy Savings (fuel oil #2)	=	18,572 MBtu
Annual Cost Savings (fuel oil #2)	=	$79,300
SIR	=	---
Simple Payback	=	---

*There are no construction costs because all that is necessary is for an operator to reset his O_2 controller. However, there may be some repermitting costs.

ECO Number: GP-X-4

INSTALL TURNING VANES IN BOILER DUCTWORK

Description

The boiler ductwork has square corners in the 90° elbows. Energy can be saved by allowing the gas to make the turns less abruptly. The energy savings will manifest itself in reduced forced draft (FD) fan and induced draft (ID) fan motor electrical consumption. The pressure drop can be reduced by replacing the existing inside right angle corner of the duct elbow with a 24-inch radius bend.

Recommendation

Based on the Life Cycle Cost Analysis, this ECO is recommended. The analysis results are listed below. Four elbows will be modified on each of the existing five boilers in powerhouse #1.

Construction Cost	=	$38,400
Annual Energy Savings (electricity)	=	2,480 MBtu
Annual Energy Cost Savings (electricity)	=	$21,998
SIR	=	6.83
Payback	=	1.67

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPX4
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-X-4 INSTALL DUCT TURNING VANES
FISCAL YEAR 1990 DISCRETE PORTION NAME: INSTALL ELBOW
ANALYSIS DATE: 10-05-90 ECONOMIC LIFE 25 YEARS PREPARED BY: G. FALLON

1. INVESTMENT

A. CONSTRUCTION COST	$	38400.
B. SIOH	$	1100.
C. DESIGN COST	$	1200.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	36630.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	36630.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	2480.	$ 21998.	11.37	250113.
B. DIST	$ 4.27	0.	$ 0.	17.06	0.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ .00	0.	$ 0.	17.52	0.
E. COAL	$ 1.61	0.	$ 0.	13.34	0.
F. TOTAL		2480.	$ 21998.		$ 250113.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 82537.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 21998.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 250113.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 6.83
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 1.67

ECO Number: GP-X-5

INSTALL THERMOSTAT CONTROL IN MOTOR HOUSES

Discussion

There are 105 motor houses at RAAP that have less than 100 square feet of area. These buildings are currently heated by steam radiators to prevent the fire protection system from freezing. These radiators are controlled by manual on/off valves and they operate 24 hours per day (regardless of outdoor air temperature) for approximately eight months per year. A thermostat control system would control the steam flow to the radiator, thus saving the excess energy used to heat the building when freeze protection is not required.

Recommendation

Based on the Life Cycle Cost Analysis, this ECO is not recommended.

Construction Cost	=	$40,273
Coal Energy Savings	=	4,602 MBtu/Yr
Coal Cost Savings	=	$7,409 Yr
Electricity Price Differential Costs	=	$3,869
Net Cost Savings	=	$3,540/Yr
SIR	=	1.33
Simple Payback	=	11.4 years

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPX5
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-X-5 INSTALL HEAT TRACING IN MOTOR HOUSES
FISCAL YEAR 1990 DISCRETE PORTION NAME: HEAT TRACE
ANALYSIS DATE: 02-05-91 ECONOMIC LIFE 25 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	40273.
B. SIOH	$	2215.
C. DESIGN COST	$	2417.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	40415.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	40415.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	11.37	0.
B. DIST	$ 4.27	0.	$ 0.	17.06	0.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ .00	0.	$ 0.	17.52	0.
E. COAL	$ 1.61	4602.	$ 7409.	13.34	98839.
F. TOTAL		4602.	$ 7409.		$ 98839.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ -3869.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ -45074.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ -45074.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 32617.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 3540.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 53765.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 1.33
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 11.42

ECO Number: GP-X-6

CHANGE TO NATURAL GAS FIRING AT THE INCINERATOR

Description

Hercules indicates a study was conducted in 1986 to change the incinerators to natural gas firing from No. 2 fuel oil. The study recommended the fuel change based on good investment payback. The payback was driven by the differential cost between natural gas and fuel oil. No energy savings are expected.

Hercules reports that they are proceeding with the project. It is currently in the preconstruction design stage. Hercules has estimated the installed cost to be $250,000.

Recommendations

Based on a Life Cycle Cost analysis, this ECO is recommended. The results are summarized below.

Construction Cost	=	$250,000
Annual Energy Savings (Fuel Oil #2)	=	86,217 MBtu/yr
Additional Energy (Natural Gas)	=	86,217 MBtu/yr
Annual Cost Savings	=	$78,457
Simple Payback	=	3.20
SIR	=	4.80

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: GPX6
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: GP-X-6 CHANGE INCINERATOR TO NATURAL GAS
FISCAL YEAR 1990 DISCRETE PORTION NAME: FUEL CHANGE
ANALYSIS DATE: 10-05-90 ECONOMIC LIFE 25 YEARS PREPARED BY: G. FALLON

1. INVESTMENT

A. CONSTRUCTION COST	$	250000.
B. SIOH	$	13750.
C. DESIGN COST	$	15000.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	250875.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	250875.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	11.37	0.
B. DIST	$ 4.27	86217.	$ 368147.	17.06	6280581.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ 3.36	-86217.	$ -289689.	17.52	-5075354.
E. COAL	$ 1.61	0.	$ 0.	13.34	0.
F. TOTAL		0.	$ 78457.		$ 1205227.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 397725.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 78457.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 1205227.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 4.80
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 3.20

ECO Number: MF-X-1

INSTALL AUTOMATIC CONTROLS FOR PREHEAT COILS ON THE FORCED AIR DRY BUILDINGS

Discussion

The Forced Air Dry (FAD) buildings use once through air, heated to 145F to remove excess solvents from multibase propellant. To maintain the proper space temperature during extremely cold outside conditions, bare pipe steam preheat coils were installed outside of the mechanical rooms in the outside air intake plenum. There are currently no controls on these coils. Forty-pound steam is turned on in October and off in May.

Automatic controls could turn the steam off when the outside air is above 40°F and the temperature is not being controlled in the FAD bay. This would reduce the operating time of the preheat coils by approximately 2,000 hours per year.

Recommendations

Based on the Life Cycle Cost Analysis, installing automatic controls on the preheat coils of the Forced Air Dry Buildings is not recommended.

Construction Cost	=	$60,871
Coal Savings	=	706 MBtu/year
Cost Savings	=	$1,137/year
Electricity Price Differential Costs	=	$204/year
Net Cost Savings	=	$933/year
Payback	=	65.5 years
SIR	=	0.16

3/91

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: MFX1
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: MF-X-1 INSTALL CONTROLS ON FAD BUILDINGS
FISCAL YEAR 1990 DISCRETE PORTION NAME: AUTOMATIC CONTROLS
ANALYSIS DATE: 02-22-91 ECONOMIC LIFE 15 YEARS PREPARED BY: W.TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	60871.
B. SIOH	$	3348.
C. DESIGN COST	$	3653.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	61085.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	61085.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	8.78	0.
B. DIST	$ 4.27	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ 1.61	706.	$ 1137.	10.01	11378.
F. TOTAL		706.	$ 1137.		$ 11378.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ -204.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ -1858.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ -1858.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 3755.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 933.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 9520.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .16
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 65.50

ECO Number: NC-U-1

INSULATE BOILING TUBS

Description

The boiling tubs are 18-feet diameter, 12-feet high stainless steel tanks used to "cook" the nitrocellulose (NC). The cooking time varies, but can be as long as 123.5 hours depending upon type of NC being produced. The cooking temperature is the saturation temperature for the tub altitude, about 205°F.

The tubs are not insulated for safety reasons. Nitrocellulose "hide-out," behind insulation for example, poses an explosion hazard. The external tank surface must be accurate for visual inspection and for washing off spilled NC. These safety requirements are not incompatible with simple insulation techniques.

The boiling tub surfaces could be insulated safely by mounting movable, washable, insulation panels one inch from the tank wall. The panels would form a curtain around the tank preventing the large heat loss now occurring. The panels could be supported by a light frame attached to the tank, or possibly hung from the operating floor. Each panel is easily moveable so the tank wall could be inspected by the operators. The insulation material is completely encased in a vinyl cover to allow in-place washing by the operators (see sketch in Appendix B).

Recommendation

Based on concerns from Hercules personnel that nitrocellulose may become trapped and create a safety hazard, this ECO is not recommended. The results of the analysis are listed below.

Construction cost	=	$66,608
Annual Energy Savings (coal)	=	6,674 MBtu
Energy Cost Savings	=	$10,745/yr

Electricity Price Differential Costs	=	$5,612/yr
Net Cost Savings	=	$5,133/yr
SIR	=	0.84
Simple Payback	=	13.02 yrs

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: NCU1
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: NC-U-1 INSULATE BOILING AND POACHING TUBS
FISCAL YEAR 1990 DISCRETE PORTION NAME: STAND-OFF INSULATION
ANALYSIS DATE: 02-22-91 ECONOMIC LIFE 15 YEARS PREPARED BY: G. FALLON

1. INVESTMENT

A. CONSTRUCTION COST	$	66608.
B. SIOH	$	3664.
C. DESIGN COST	$	3997.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	66842.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	66842.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	8.78	0.
B. DIST	$ 4.27	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ 3.36	0.	$ 0.	12.48	0.
E. COAL	$ 1.61	6674.	$ 10745.	10.01	107559.
F. TOTAL		6674.	$ 10745.		$ 107559.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ -5612.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ -51125.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ -51125.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 35494.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 5133.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 56434.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= .84
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 13.02

ECO Number: NC-X-1

MODIFY BOILING TUB HEATING METHOD

Description

The boiling tubs are currently heated by directly injecting steam below the water level in the "perk" (percolation) line. The steam pushes the water up and out of the line while simultaneously heating it. Once all of the water has been ejected from the "perk" line, the steam freely vents from end of the line with a large puff of vapor that escapes from the boiling tub through unsealed cracks in the tub roof opening covers. Calculations indicate 81 percent (1.6 MMBtu/hr) of the heat loss from the boiling tub is due to "puffing" because the escaping vapor contains about 1,000 Btu/# of steam.

Installation of a closed heat exchanger and pump in lieu of the percolation approach would save nearly all of the above heat loss. Various heat exchanger types could be evaluated to provide the safest design. The approach suggested here is both safe and simple. The proposed heat exchanger is simply a pipe within a pipe that would follow the route of the existing "perk" line. Steam (40 psig) would enter the outer pipe at the top and condensate would exit the bottom. By condensing the steam, the 1,000 Btu/lb of steam would be recovered. Tub fluid flows upward from the bottom the way it does now (see the diagrams on the following pages). The new pump is a centrifugal, in-line, magnetically coupled (zero leak) pump. The pump capacity is approximately 100 gpm at 20 feet of head. The motor required is about one horsepower.

Recommendation

Based on the Life Cycle Cost Analysis, modifications to the boiling tub heating method is recommended. Results of the analysis are below:

Construction Cost = $115,994

BOILING TUB

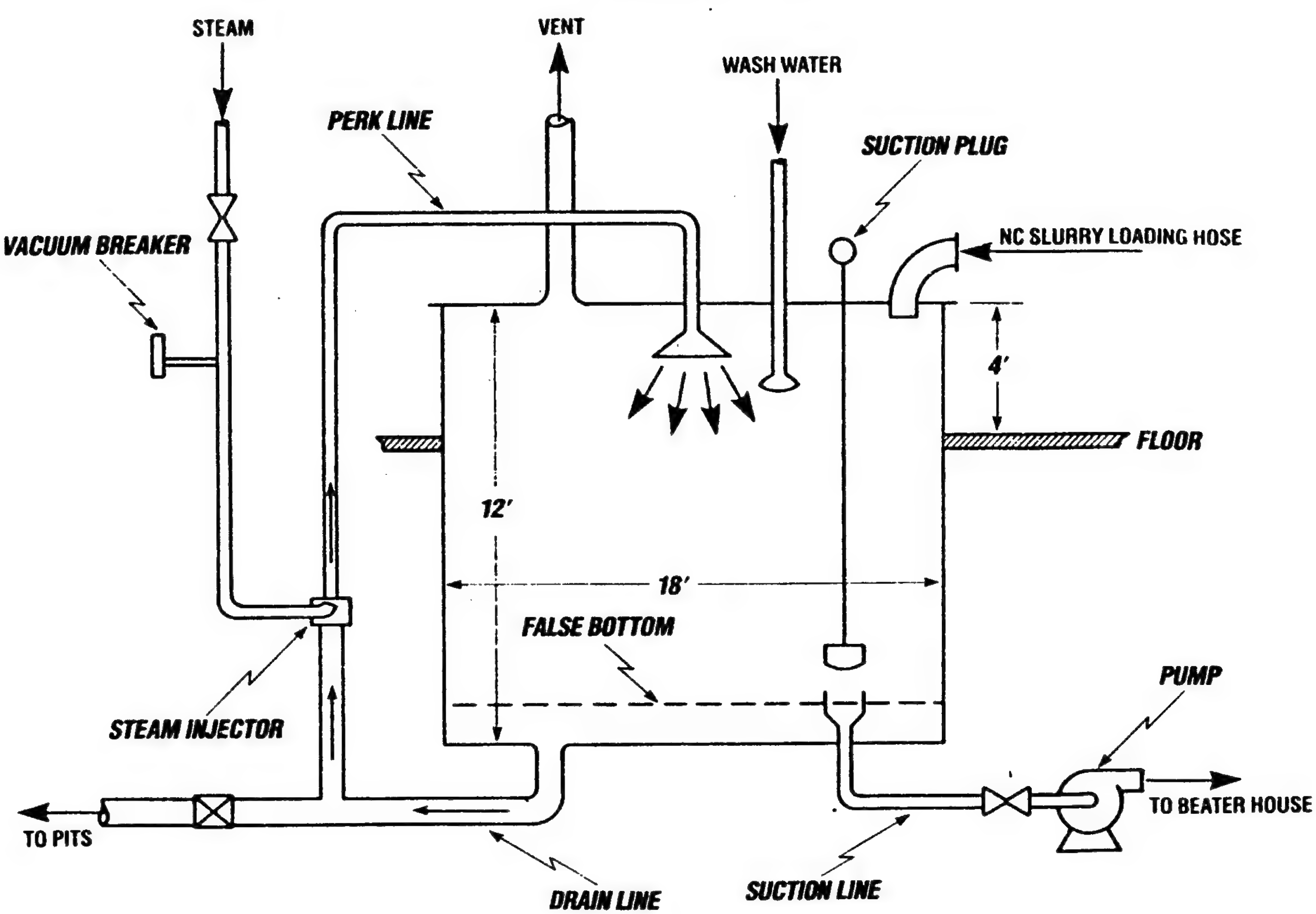


FIGURE 4-2

Radford Army Ammunition Plant
Boiling Tub Heat Exchanger

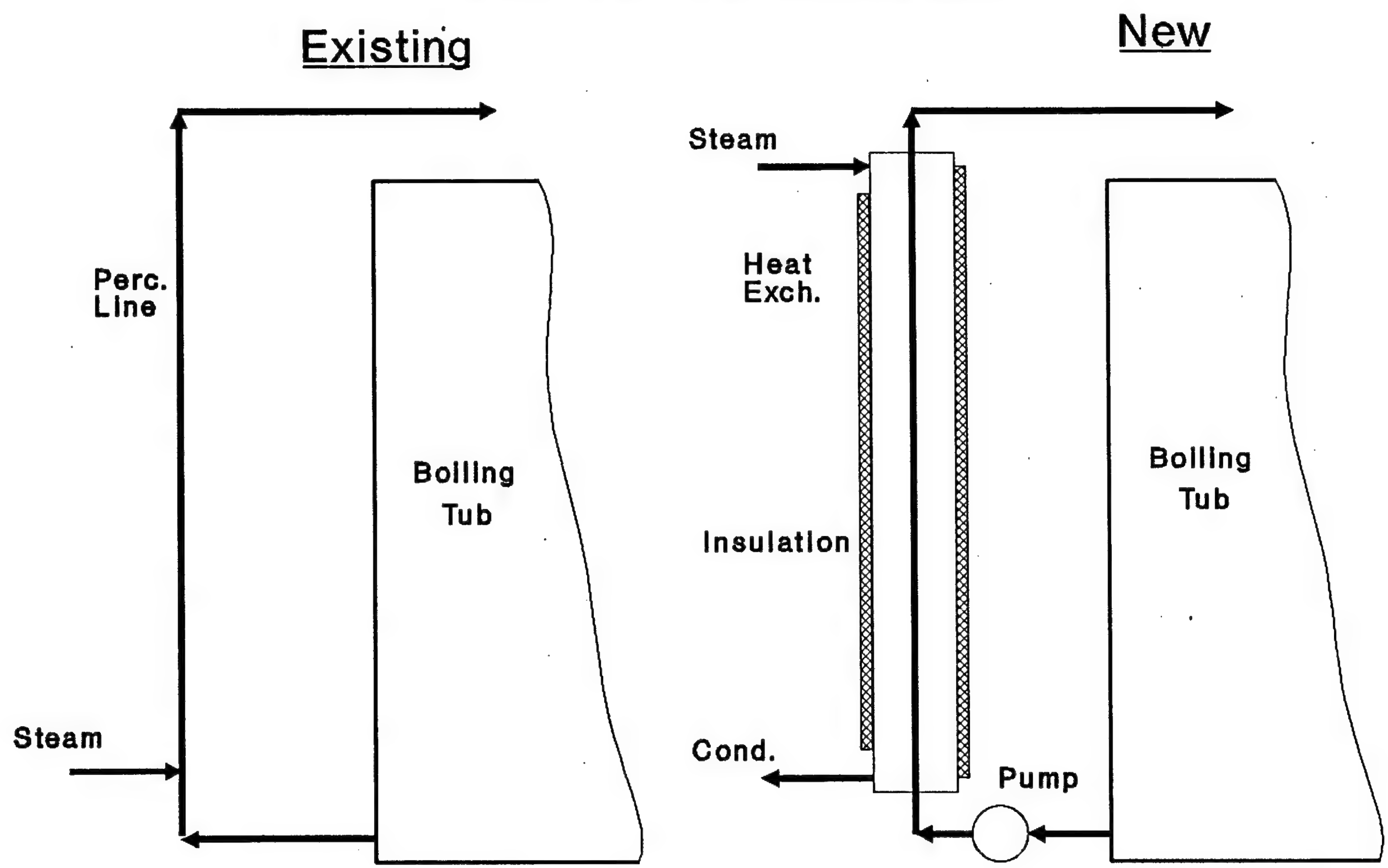


FIGURE 4-3

Annual Energy Savings (coal)	=	123,431 MBtu
Energy Cost Savings	=	$198,724/yr
Electricity Price Differential Costs	=	$103,797/yr
Net Cost Savings	=	$94,927/yr
SIR	=	8.97
Simple Payback	=	1.23 years

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: NCX1
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: NC-X-1 MODIFY BOILING TUB HEATING
FISCAL YEAR 1990 DISCRETE PORTION NAME: HEAT EXCHANGER
ANALYSIS DATE: 02-19-91 ECONOMIC LIFE 15 YEARS PREPARED BY: G.FALLON

1. INVESTMENT

A. CONSTRUCTION COST	$	115994.
B. SIOH	$	6380.
C. DESIGN COST	$	6960.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	116401.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	116401.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	0.	$ 0.	8.78	0.
B. DIST	$ 4.27	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ 3.36	0.	$ 0.	12.48	0.
E. COAL	$ 1.61	123431.	$ 198724.	10.01	1989226.
F. TOTAL		123431.	$ 198724.		$ 1989226.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ -103797.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ -945591.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ -945591.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 656445.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 94927.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 1043636.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 8.97
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 1.23

ECO Number: SR-I-1

REMOVE STEAM COILS FROM THE ACTIVATED CARBON SOLVENT RECOVERY DUCTWORK

Discussion

Steam heating coils were built into the activated carbon solvent recovery process to precondition the air entering the charcoal tanks, and also for freeze protection. Discussions with the maintenance staff indicated that these coils were no longer utilized and the steam supply was shut off. These coils add to the total pressure that the 450-horsepower fan motors must overcome.

Significant electrical energy savings would be realized if the steam coils were removed, replaced with ductwork, and the fan drive adjusted to provide the design air flow for the lower system air friction.

Recommendations

Based on the Life Cycle Cost Analysis, it is recommended that the steam heating coils in the activated carbon solvent recovery ductwork be removed and the fan drives adjusted to attain the design air flow.

Construction Cost	=	$16,997
Annual Energy Savings (electricity)	=	1,576 MBtu
Energy Cost Savings	=	$13,979/yr
SIR	=	7.20
Simple Payback	=	1.22

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: REMCOILS
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: SR-I-1 REMOVE STEAM COILS FROM ACSR DUCTWORK
FISCAL YEAR 1990 DISCRETE PORTION NAME: ACT. CARBON SOL. REC. BLDGS.
ANALYSIS DATE: 09-25-90 ECONOMIC LIFE 15 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	$	16997.
B. SIOH	$	935.
C. DESIGN COST	$	1020.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	17057.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	17057.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	1576.	$ 13979.	8.78	122737.
B. DIST	$ 4.27	0.	$ 0.	12.34	0.
C. RESID	$ .00	0.	$ 0.	12.05	0.
D. NAT G	$ .00	0.	$ 0.	12.48	0.
E. COAL	$ 1.61	0.	$ 0.	10.01	0.
F. TOTAL		1576.	$ 13979.		$ 122737.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 9.11
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 40503.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 13979.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 122737.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 7.20
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 1.22

4.2 EEAP Study Update

An Energy Engineering Analysis Program (EEAP) was accomplished by Hayes, Seay, Mattern and Mattern and documented in a report dated January 1982. Three projects were recommended that are to be updated in this report:

- o T-102-G, Replacement and installation of gate valves
- o T-108, Change house modifications
- o WO-114G, Water dry tank covers

Replacement and Installation of Gate Valves

The project involves replacement of 137 gate valves and installation of one new valve in the "A" line powder area and four in the (Increment No. 1) first rolled powder area.

All known valves that were leaking have been either repaired or replaced by Hercules. Steam is now "valved off" to prevent flow to unneeded areas or buildings.

Change House Modifications

This project called for the installation of new fluorescent lighting to replace existing incandescent systems. This project has been accomplished.

Water Dry Tank Covers

Water dry tanks are open to the atmosphere, allowing heated water vapor and ether to escape during the drying cycles. This project would provide a fiberglass tank cover designed to collect the ether. Chilled water coils would condense the ether on the underside of the cover allowing the liquid ether to return to the tank.

This project has been rejected by RAAP engineering staff as not meeting existing safety requirements.

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LIFE CYCLE COST ANALYSIS SUMMARY STUDY: 1234
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.035
INSTALLATION & LOCATION: RADFORD AAP REGION NOS. 3 CENSUS: 3
PROJECT NO. & TITLE: 1234 REPLACE AND INSTALL GATE VALVES
FISCAL YEAR 1990 DISCRETE PORTION NAME: ADJUST CONTROLS
ANALYSIS DATE: 10-22-90 ECONOMIC LIFE 25 YEARS PREPARED BY: HUTCHINS

1. INVESTMENT

A. CONSTRUCTION COST	$	153357.
B. SIOH	$	8435.
C. DESIGN COST	$	9202.
D. ENERGY CREDIT CALC (1A+1B+1C)X.9	$	153895.
E. SALVAGE VALUE COST	-$	0.
F. TOTAL INVESTMENT (1D-1E)	$	153895.

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 8.87	-377.	$ -3344.	11.37	-38021.
B. DIST	$ 4.27	0.	$ 0.	17.06	0.
C. RESID	$ .00	0.	$ 0.	16.85	0.
D. NAT G	$ .00	0.	$ 0.	17.52	0.
E. COAL	$ 1.61	21018.	$ 33839.	13.34	451412.
F. TOTAL		20641.	$ 30495.		$ 413391.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 11.65
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+) /COST(-) (3A2+3Bd4) $ 0.

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ 136419.
A IF 3D1 IS = OR > 3C GO TO ITEM 4
B IF 3D1 IS < 3C CALC SIR = (2F5+3D1)/1F)= ______
C IF 3D1B IS = > 1 GO TO ITEM 4
D IF 3D1B IS < 1 PROJECT DOES NOT QUALIFY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1D/(YEARS ECONOMIC LIFE)) $ 30495.

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 413391.

6. DISCOUNTED SAVINGS RATIO (SIR)=(5 / 1F)= 2.69
(IF < 1 PROJECT DOES NOT QUALIFY)

7. SIMPLE PAYBACK PERIOD (ESTIMATED) SPB=1F/4 5.05

4.3 Operations and Maintenance Energy Savings

4.3.1 Energy Savings Ideas

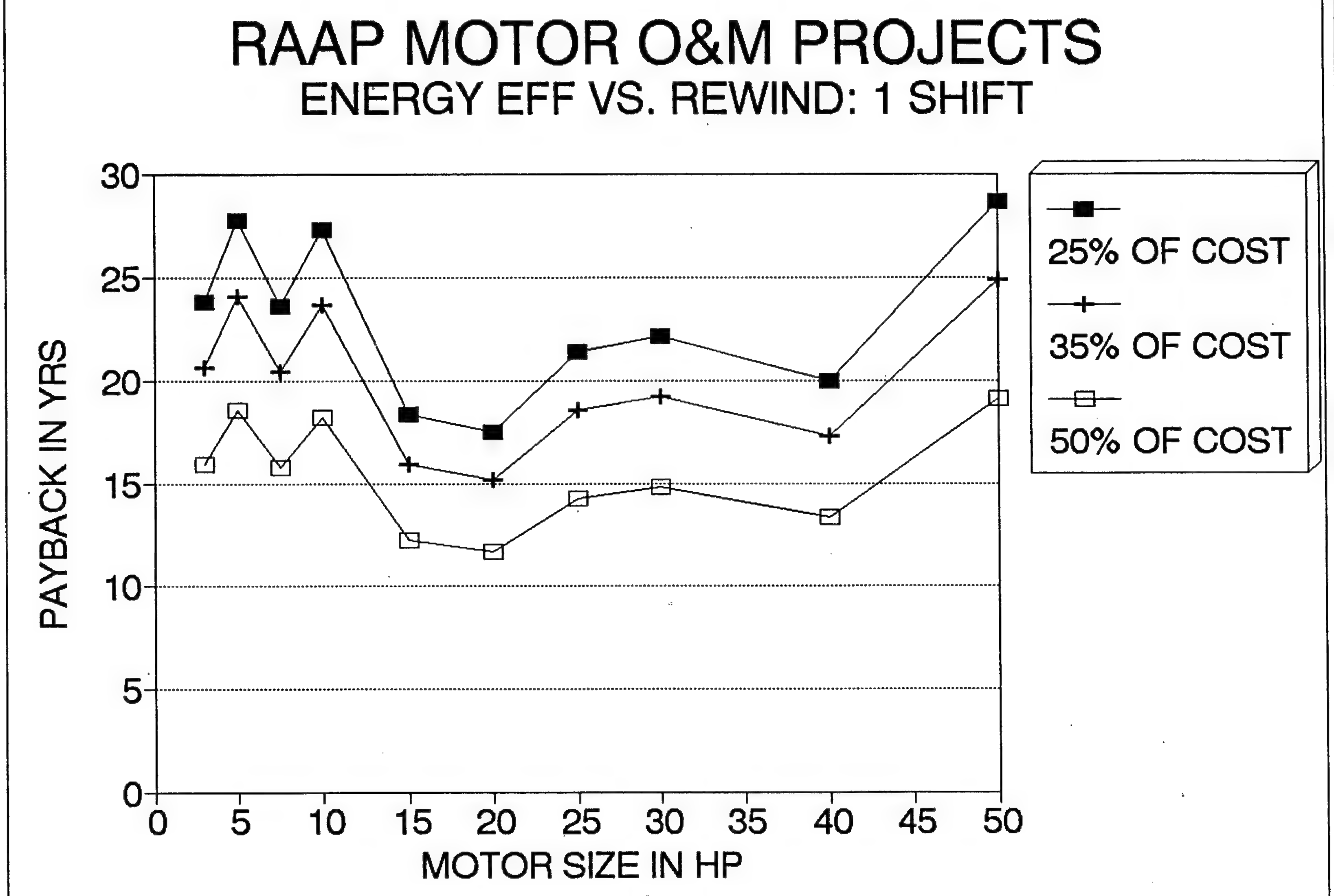
As a result of the site visits to Radford AAP, several operations and maintenance (O&M) energy savings ideas were identified. Energy and economic analyses were performed. The results of these analyses are presented below.

- Upon Failure, Rewind or Purchase a New Energy-Efficient Motor

The current practice is to rewind all motors unless the cost of the rewind is greater than 50 percent of the cost of a new motor. Analysis shows that this decision depends on the motor utilization (see Figures 4-4 through 4-9). For one-shift operation, the cost of rewind would have to be greater than 75 percent of the cost of a new energy-efficient motor. For a two-shift operation, the 50-percent value is reasonable. For three-shift operation, it is economical to purchase new motors if the cost of rewind exceeds 25 percent for motors less than 200 horsepower. For detailed calculations, see ECO GP-B-3, Appendix B.

- Upon Failure, Replace Standard Fluorescent Lamps with Energy-Efficient Types

Current practice is to replace failed fluorescent lamps with standard 40 W lamps. Replacing failed lamps with 34 W lamps saves about $1.13 per year for each lamp. The incremental cost is the difference between the cost of the two lamps, which is $0.75 per lamp. This yields a payback of about 8-1/2 months. Detailed calculations are in Appendix B, GP-N-4.



RAAP MOTOR O&M PROJECTS
ENERGY EFF VS. REWIND: 1 SHIFT
PAYBACK IN YRS
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40
45
50
MOTOR SIZE IN HP
25% OF COST
35% OF COST
50% OF COST

FIGURE 4-4

RAAP MOTOR O&M PROJECTS
ENERGY EFF VS. REWIND: 1 SHIFT

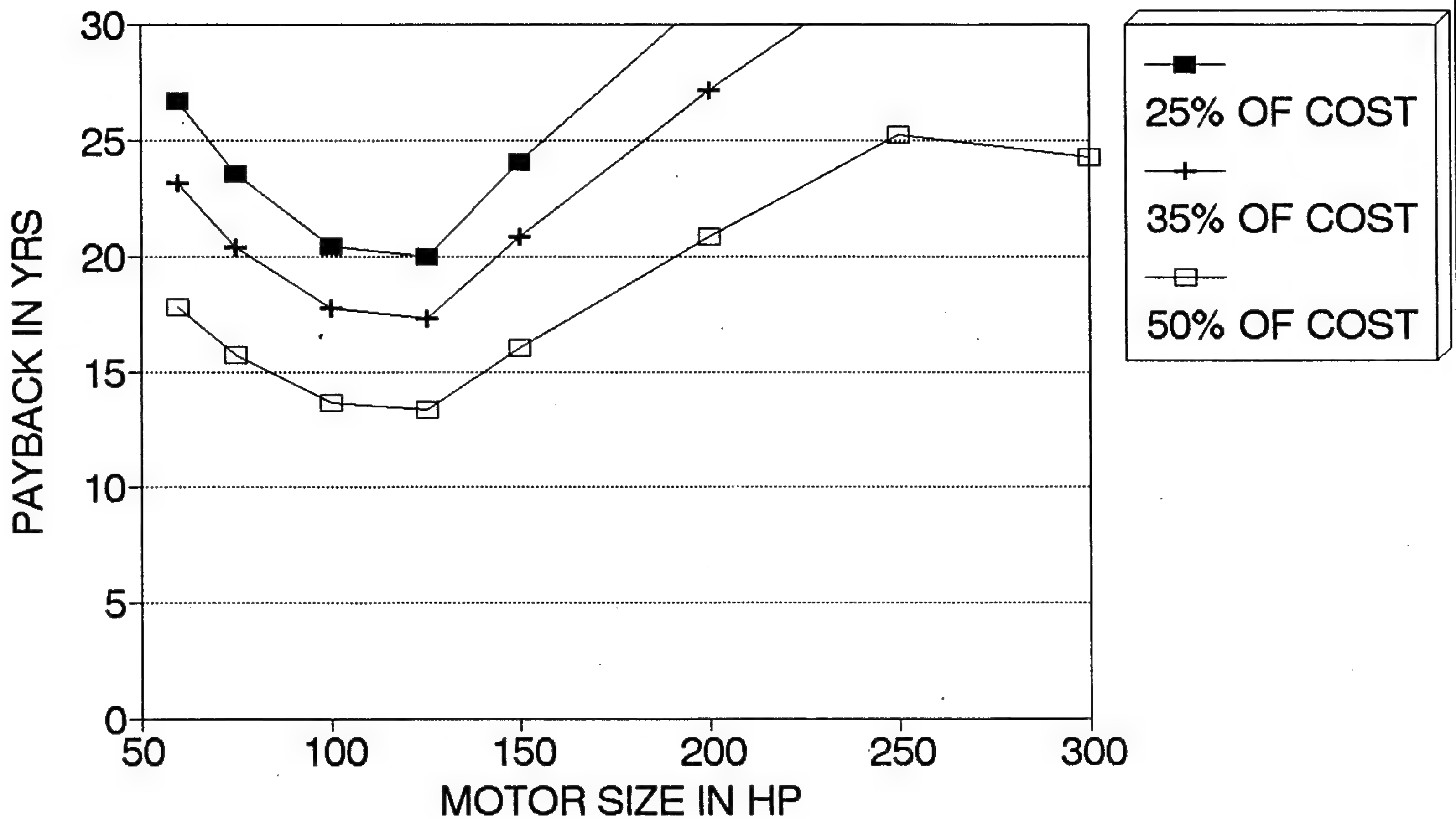


FIGURE 4-5

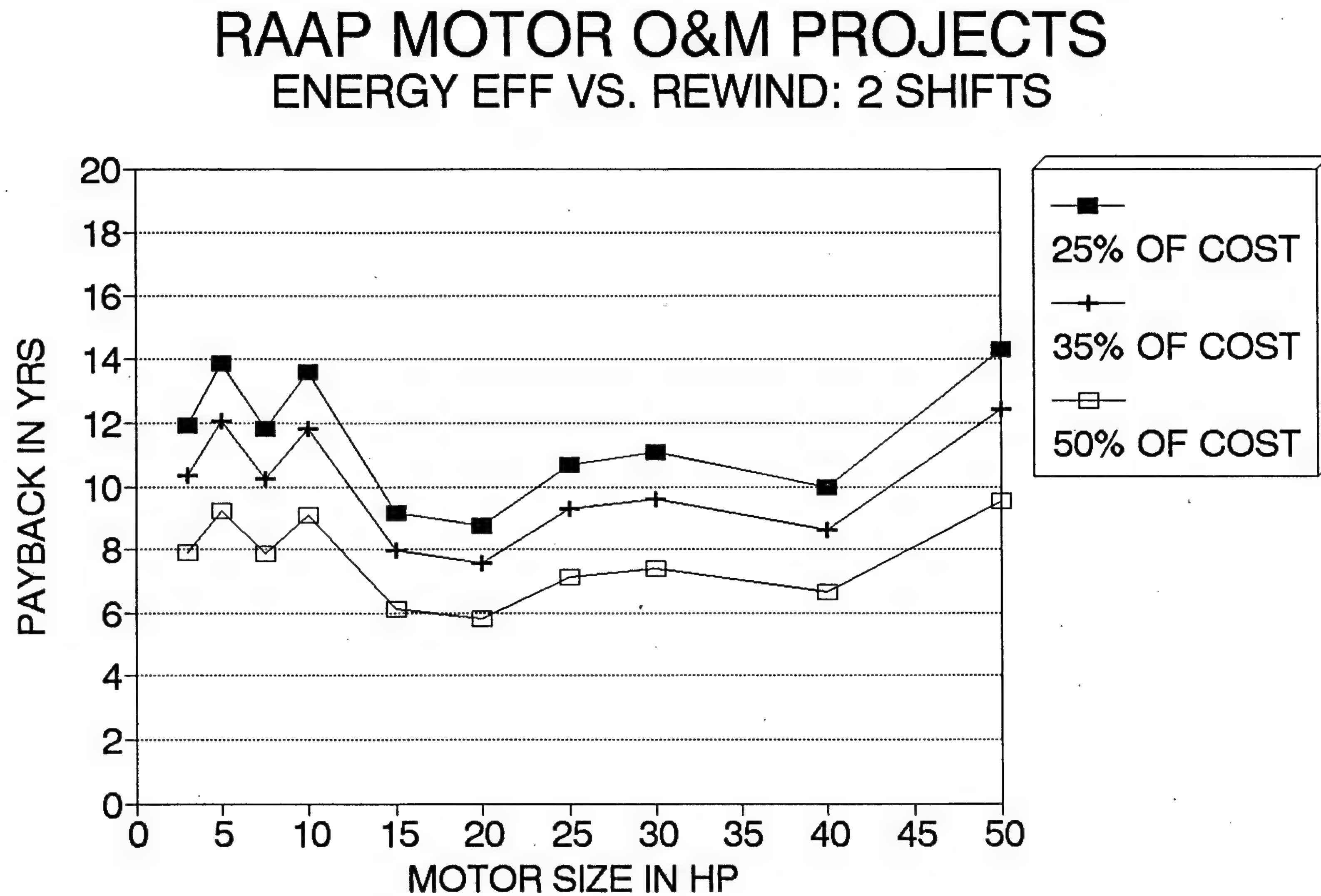
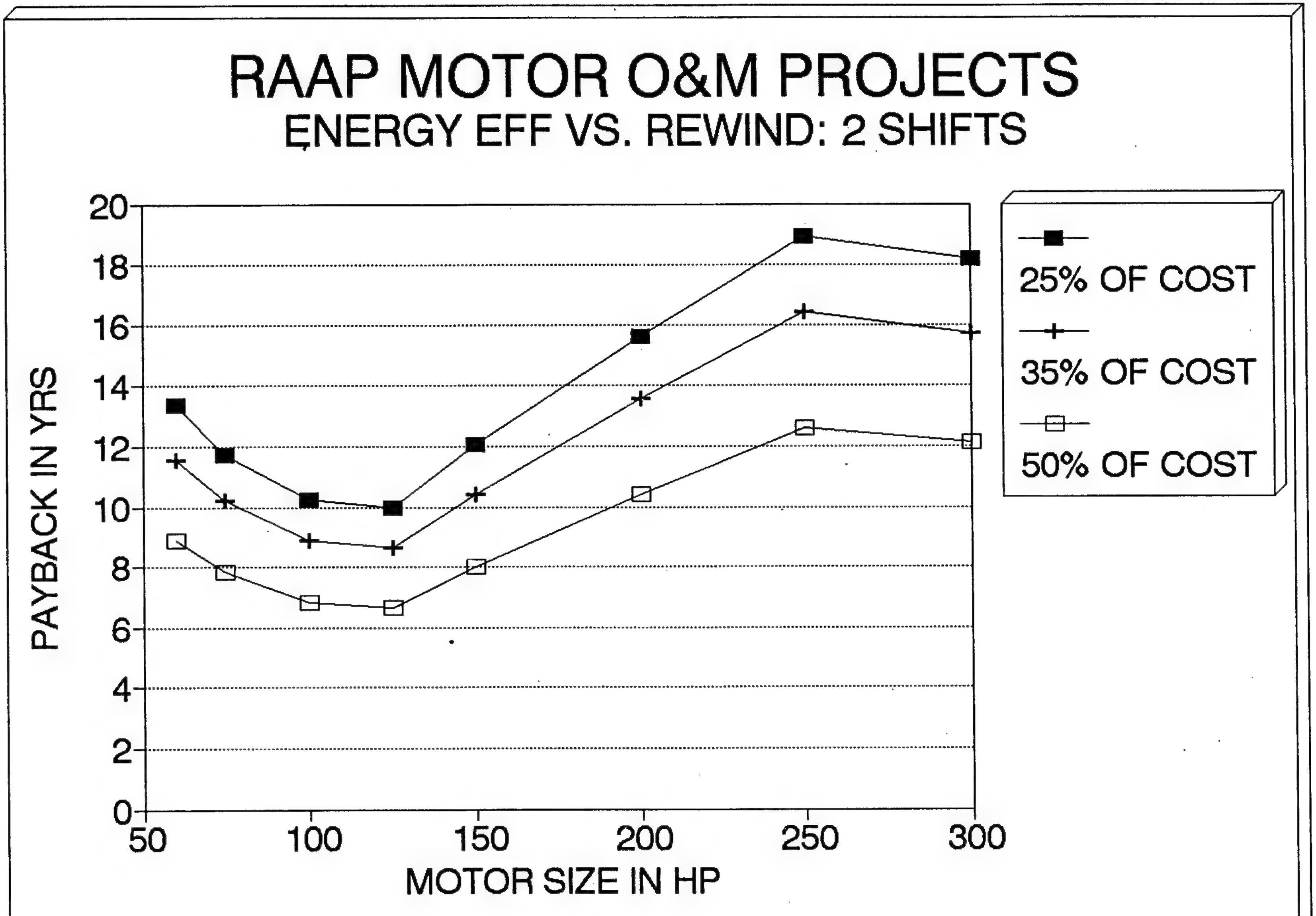

RAAP MOTOR O&M PROJECTS
ENERGY EFF VS. REWIND: 2 SHIFTS
PAYBACK IN YRS
20
18
16
14
12
10
8
6
4
2
0
0
5
10
15
20
25
30
35
40
45
50
MOTOR SIZE IN HP
25% OF COST
35% OF COST
50% OF COST

FIGURE 4-6



RAAP MOTOR O&M PROJECTS
ENERGY EFF VS. REWIND: 2 SHIFTS
PAYBACK IN YRS
20
18
16
14
12
10
8
6
4
2
0
50
100
150
200
250
300
MOTOR SIZE IN HP
25% OF COST
35% OF COST
50% OF COST

FIGURE 4-7

RAAP MOTOR O&M PROJECTS
ENERGY EFF VS. REWIND: 3 SHIFTS

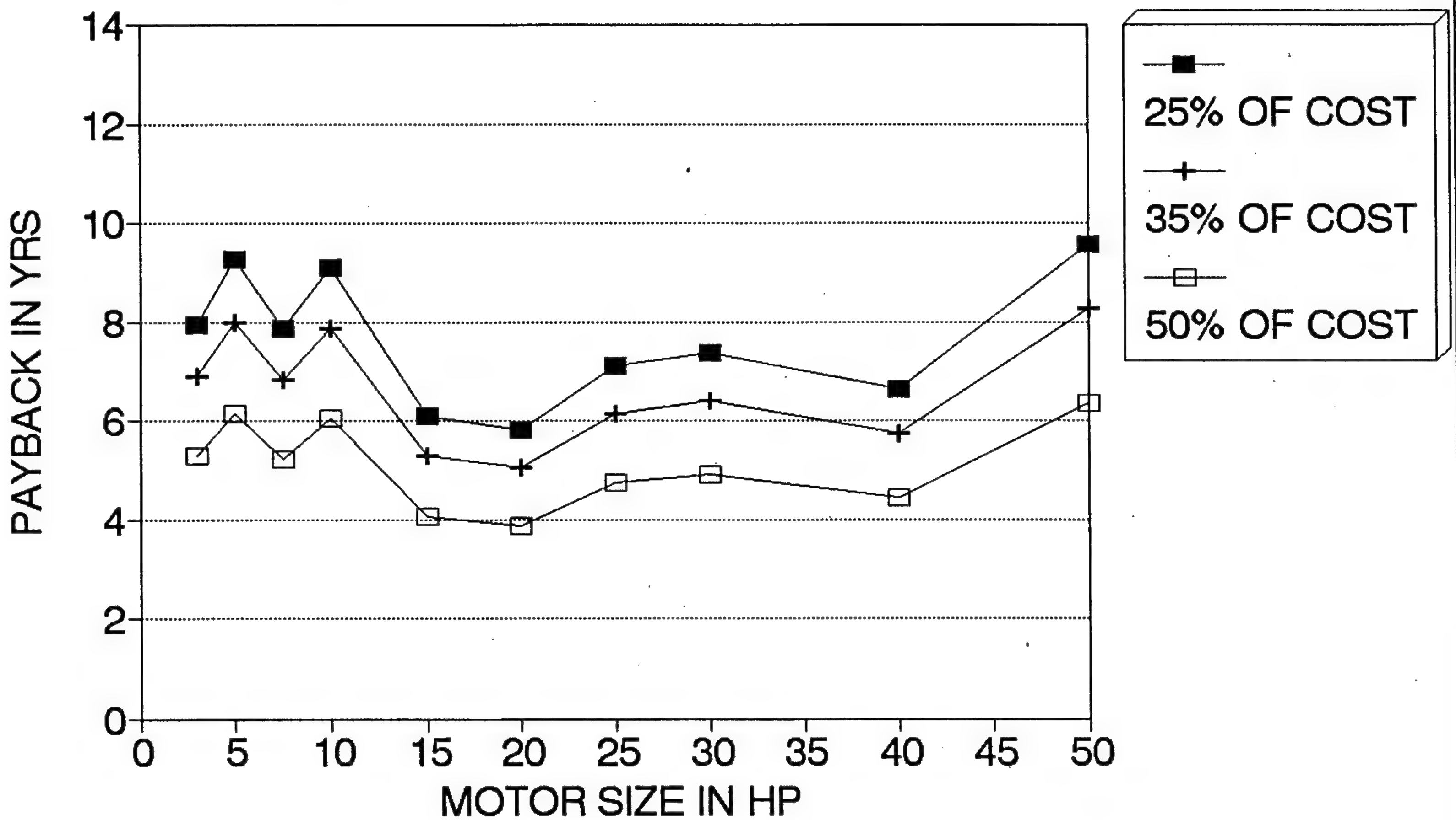


FIGURE 4-8

RAAP MOTOR O&M PROJECTS
ENERGY EFF VS. REWIND: 3 SHIFTS

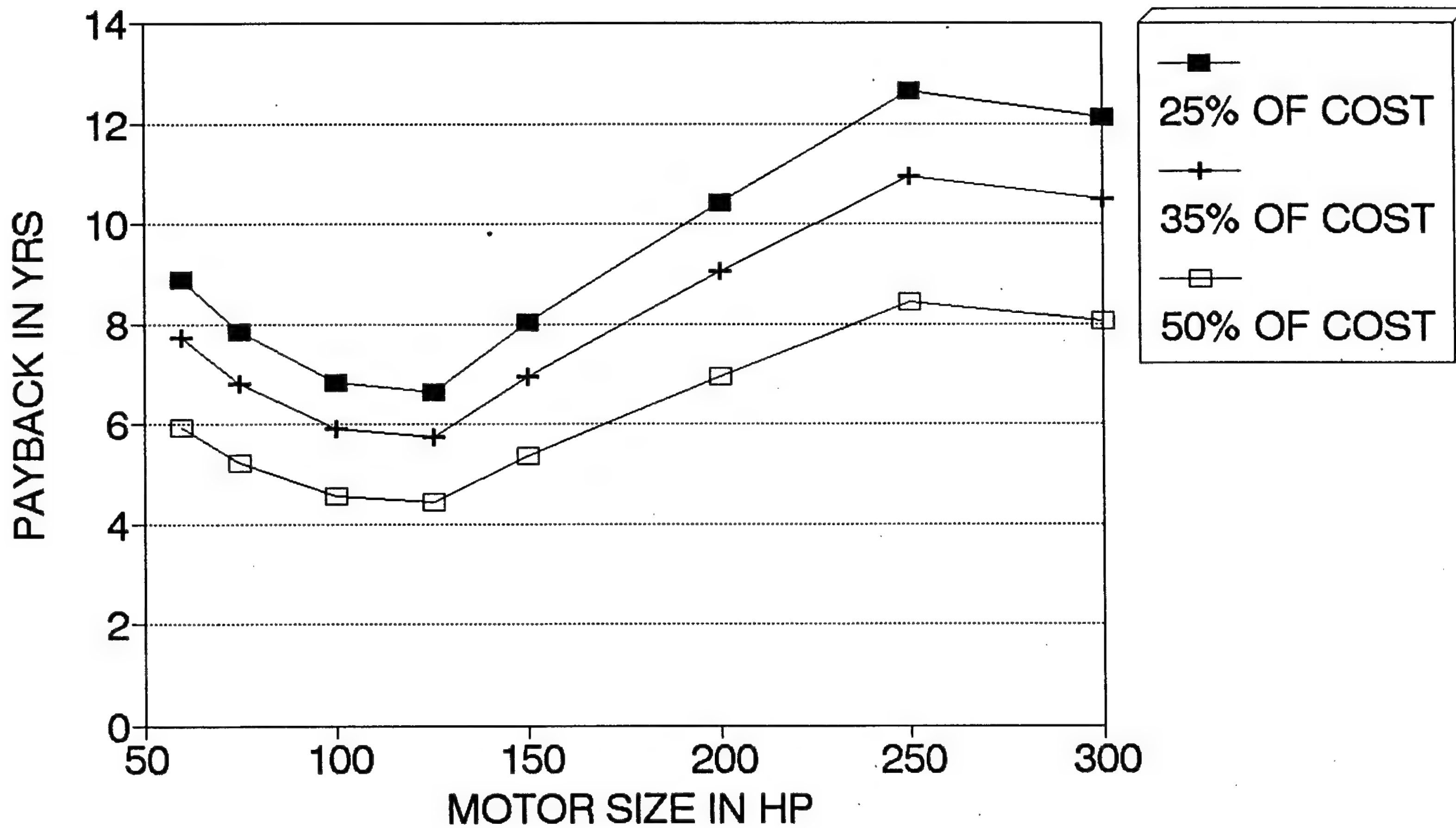


FIGURE 4-9

- Upon Failure, Replace Standard Fluorescent Fixture Ballasts with Energy-Efficient Types

Currently, fluorescent fixtures use standard ballasts. By replacing these ballasts with energy efficient types when they fail, installation charges are avoided and a 20-percent reduction in energy use is accomplished. Estimated savings are about 13 watts per two-lamp fixture or $2.45 per fixture per year. The cost is the difference between energy-efficient and standard ballasts, which is about $6.67 per ballast. This yields a simple payback of 2.7 years. Detailed calculations are in Appendix B, ECO GP-N-5.

- Upon Failure, Replace Standard Electric Motors with Energy-Efficient Types

The current policy is to replace a failed motor that cannot be economically repaired with a standard type. Energy-efficient motors offer efficiency improvements of three to nine percent and carry a cost premium of 50 to 60 percent over standard motors. The cost-effectiveness of this policy depends on the utilization of the motor, and this is shown in Figures 4-10 and 4-11. The results indicate that energy-efficient types should be purchased for all motors operating greater than one shift per day. Detailed calculations are in Appendix B, GP-B-2.

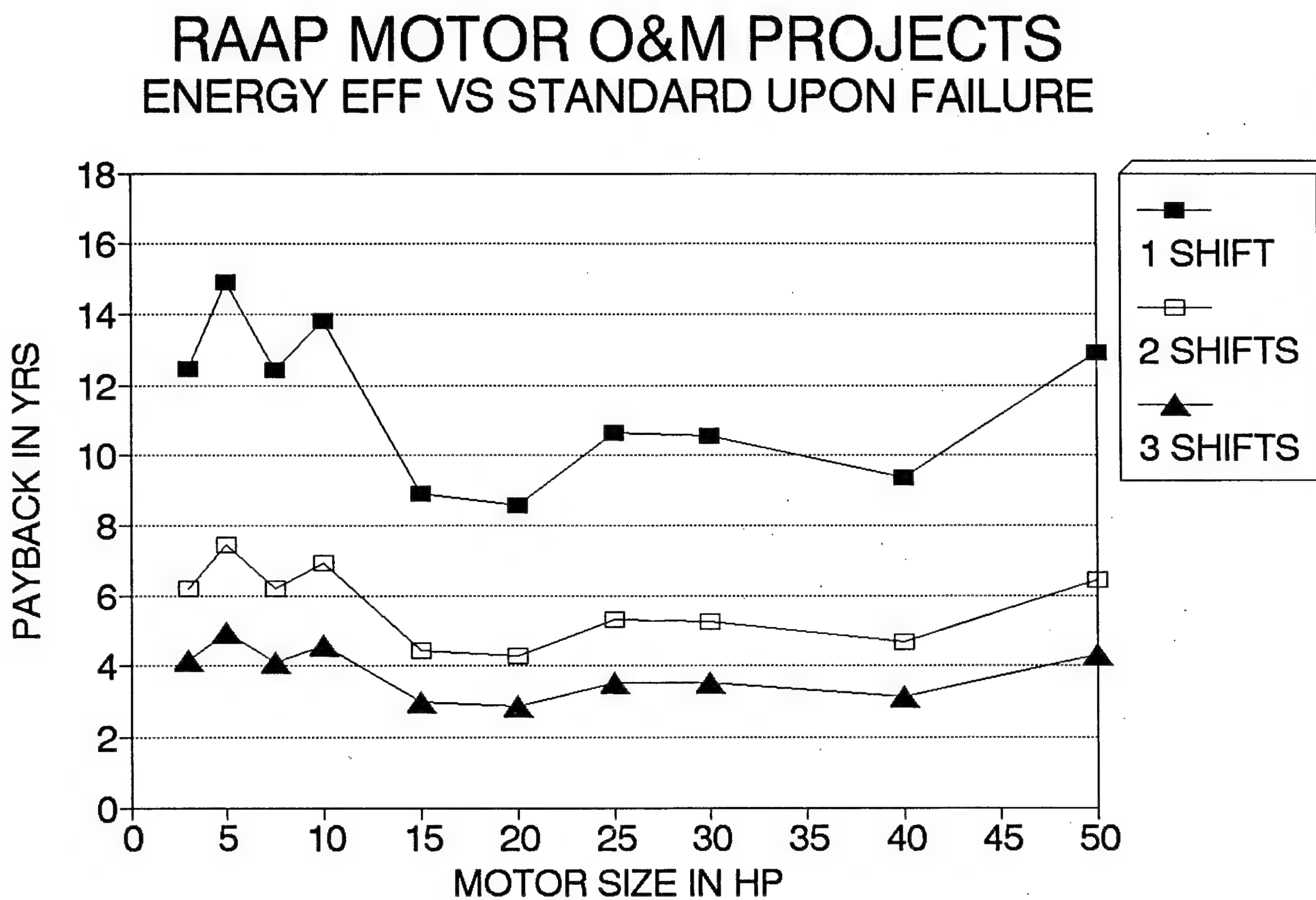
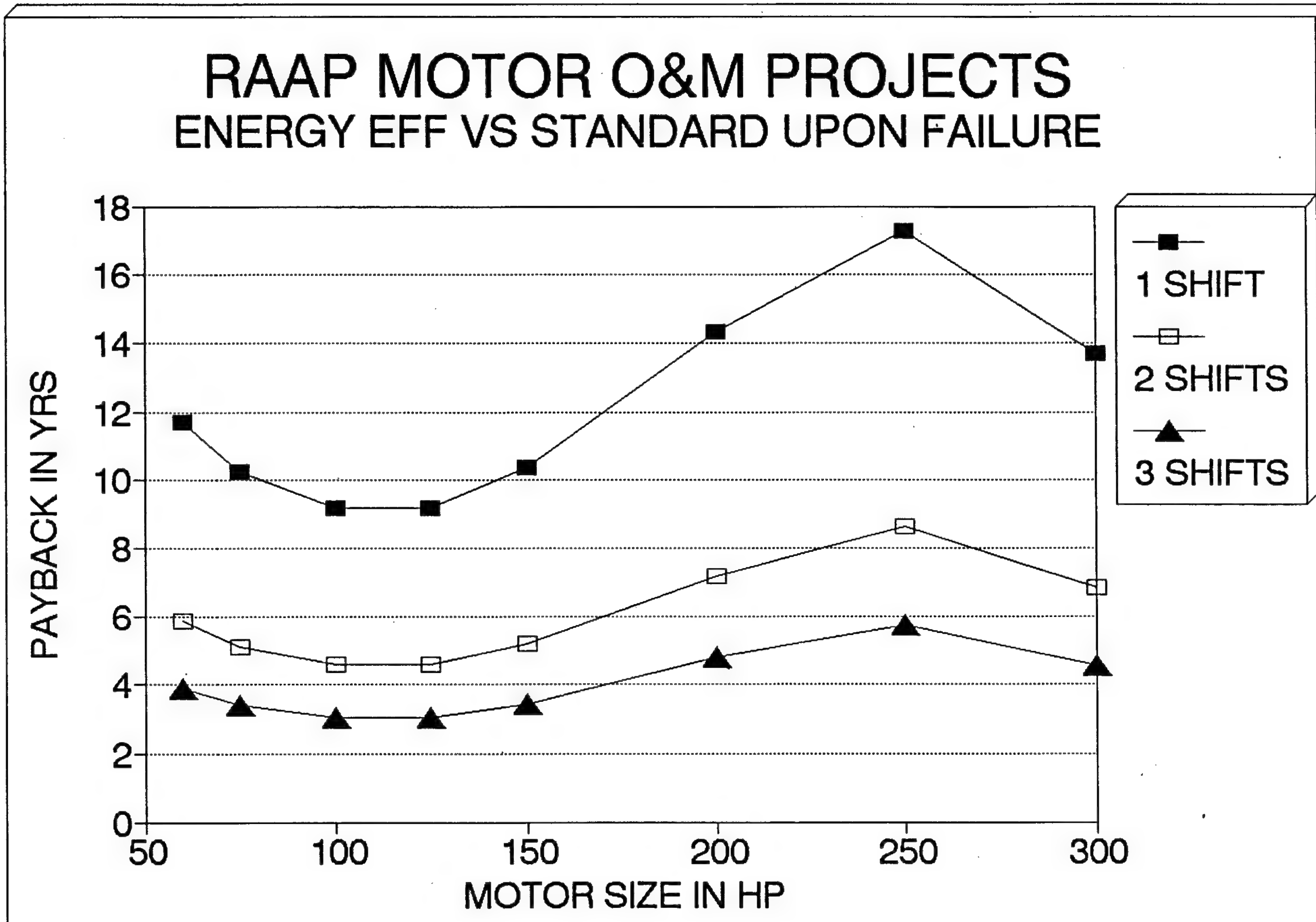

RAAP MOTOR O&M PROJECTS
ENERGY EFF VS STANDARD UPON FAILURE
PAYBACK IN YRS
18
16
14
12
10
8
6
4
2
0
0
5
10
15
20
25
30
35
40
45
50
MOTOR SIZE IN HP
1 SHIFT
2 SHIFTS
3 SHIFTS

FIGURE 4-10



RAAP MOTOR O&M PROJECTS
ENERGY EFF VS STANDARD UPON FAILURE
PAYBACK IN YRS
0
2
4
6
8
10
12
14
16
18
50
100
150
200
250
300
MOTOR SIZE IN HP
1 SHIFT
2 SHIFTS
3 SHIFTS

FIGURE 4-11

- Reduce the Exit Gas Temperatures on the Waste Propellant Incinerators

Waste propellant is carried to the incinerators mixed with water. Fuel oil is burned to evaporate this water and incinerate the waste propellant. The existing practice is to operate the incinerator at an exit gas temperature of about 1400°F. This temperature can be lowered by reducing the fuel oil flow to the burners. The energy dollars saved are shown in Figure 4-12. If the exit gas temperature is reduced to 500°F, the annual energy savings are $78,000. The existing permits may not allow this temperature reduction, but at $78,000 per year, it is worthwhile to pursue modifying the permit. Detailed calculations are in Appendix B, ECO GP-X-1.

- Reduce the Amount of Oxygen in the Waste Propellant Incinerator Exit Gas

The waste propellant incinerator currently operates with an exit gas oxygen level of 15 percent. Efficient operation of #2 fuel oil combustion equipment requires about three percent oxygen. Reducing this level by a simple adjustment of the combustion controls will save about $80,000 per year (Figure 4-13). Detailed calculations are in Appendix B, ECO GP-X-3.

- Power House #1 Operation

Power House #1 generates both steam and electricity for Radford AAP. It is the current practice to generate steam required to meet the plant demands. The resulting power generated by supplying steam turbines 400 psia steam is also utilized by the plant. The balance is purchased from the utility.

There are two types of turbines, backpressure (non-condensing) and condensing. The amount of steam sent to the condensing stage is minimized, since this is the least efficient stage of the turbine. Also, excess

Radford Army Ammunition Plant
Incinerator Fuel Cost vs Exit Gas Temp.

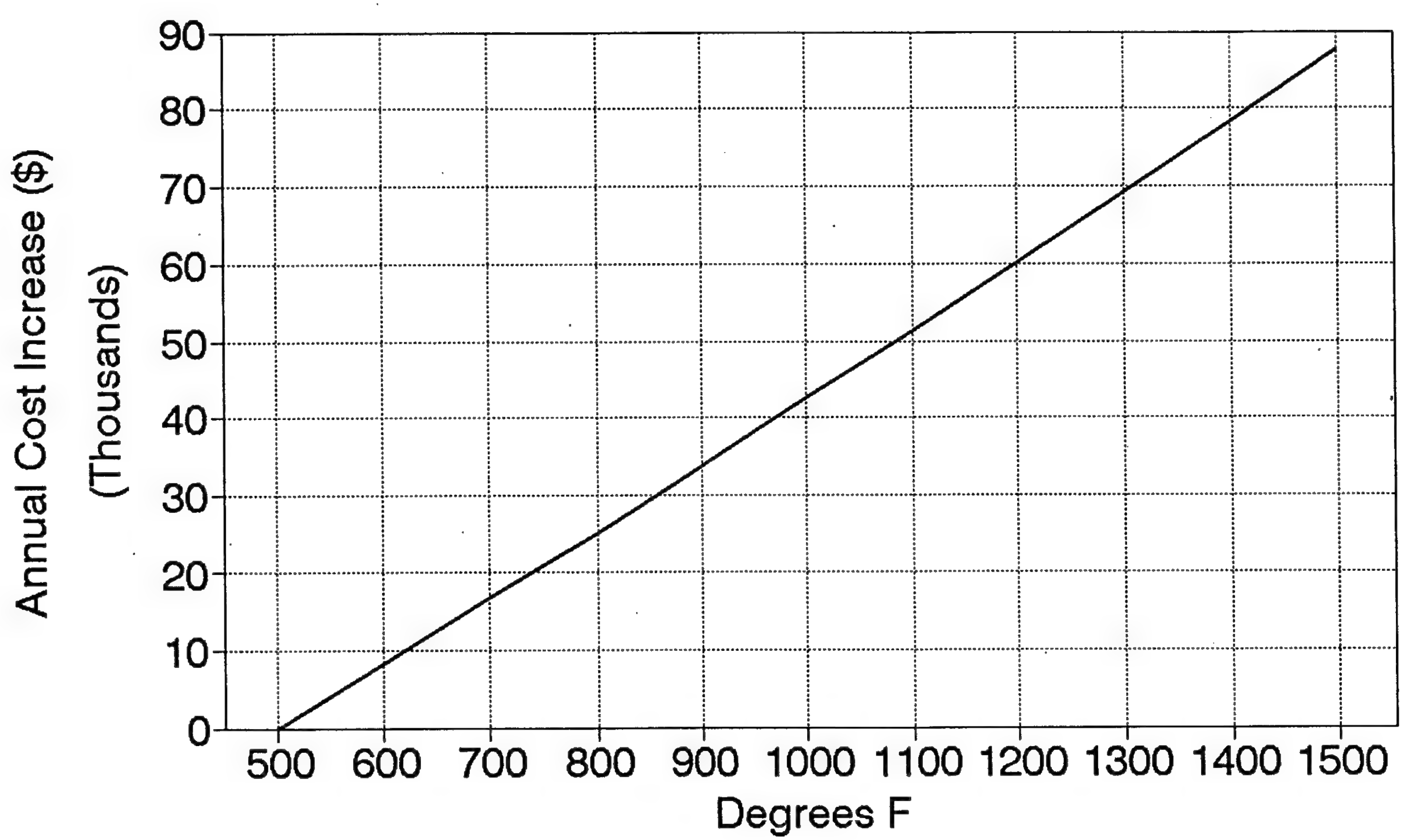


Figure 4-12

Radford Army Ammunition Plant
Incinerator Fuel Cost vs O2 in Flue Gas

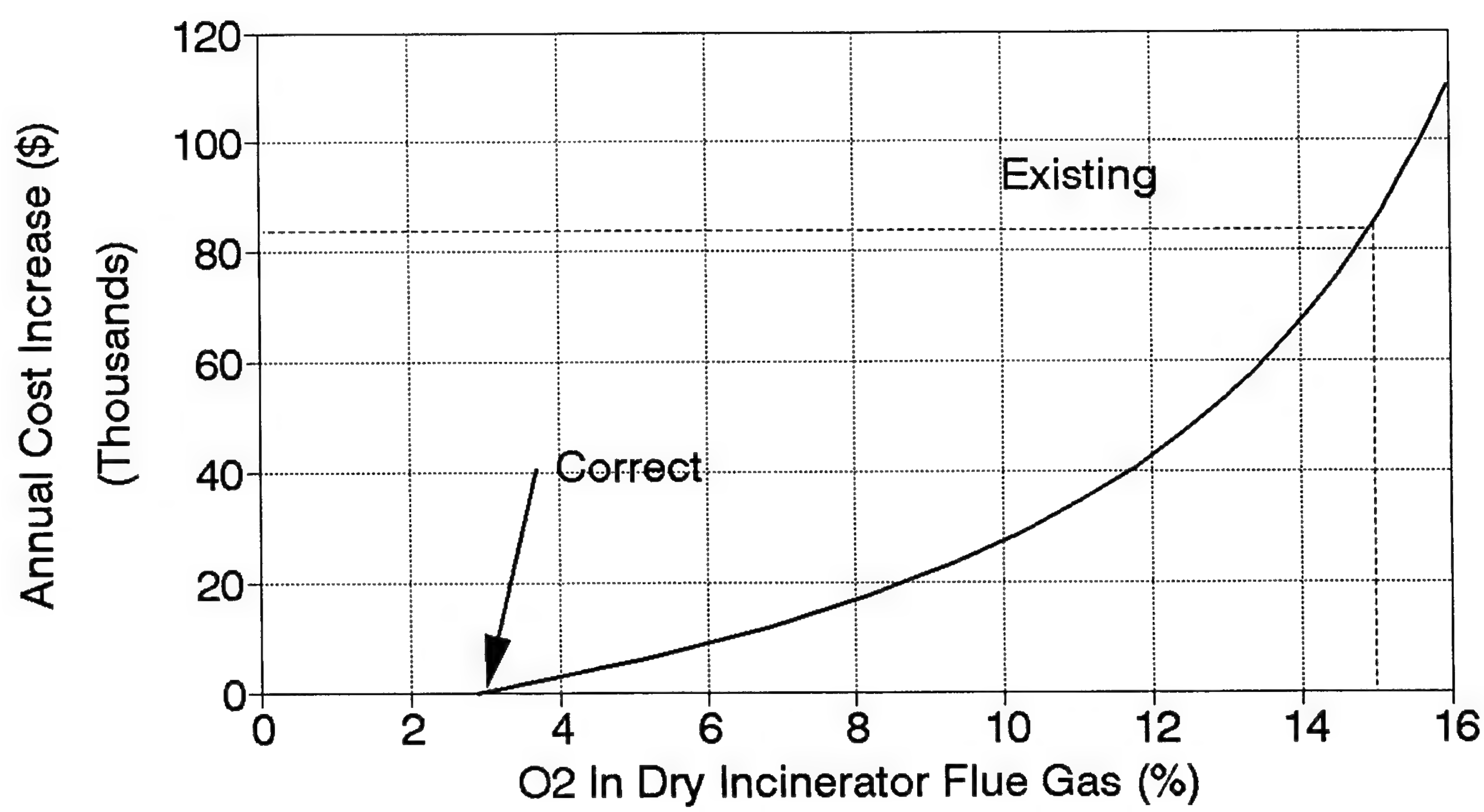


Figure 4-13

condensing during low power demand periods could cause Radford AAP purchases to fall below its contracted minimum of 7,800 kW.

However, an analysis of the turbine/generator performance curves (see Appendix B Steam-to-Coal Conversion Factors) supplied by Radford shows that if the flow to the condensing section is small enough, the efficiency of that stage drops rapidly. Figure 4-14 shows the approximate fuel cost of power generated for different flows to the condenser. The shape of this curve indicates that flow to the condensing section should never drop below 15,000 pounds per hour and should probably remain around 20,000 pounds per hour. Operating at 10,000 pounds per flow to the condenser could cost up to $16,000 annually.

Radford Army Ammunition Plant

Turbine Condensing Section Performance

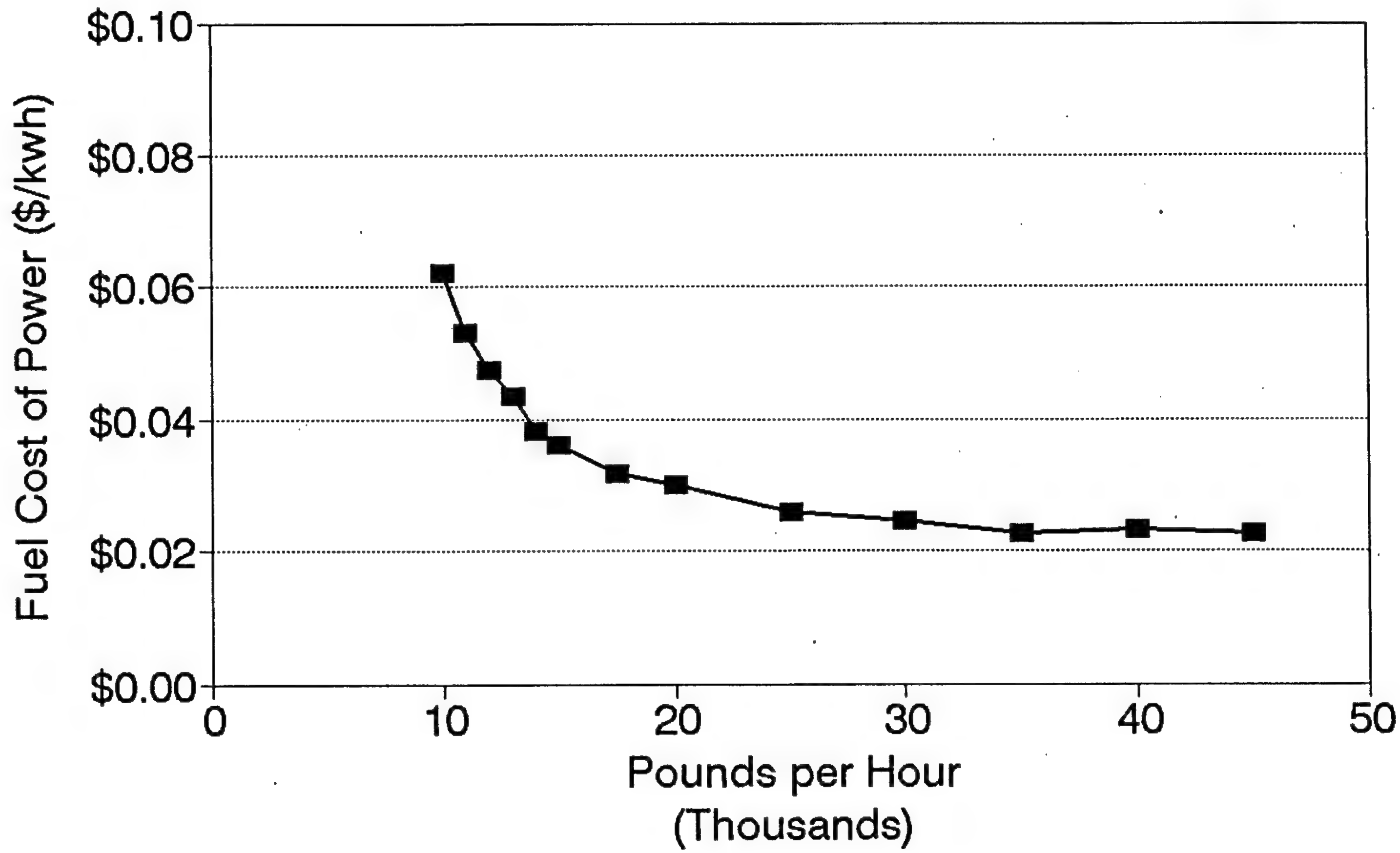


FIGURE 4-14

4.3.2 Operations and Maintenance Instruction Outline

A presentation will be made to Radford AAP personnel discussing energy savings in operations and maintenance covering the ideas discussed in this section. Below is an outline of the topics that will be presented.

1. Radford EEAP Industrial Facilities Study description and purpose
2. Radford AAP energy use data and statistics
3. Fluorescent lighting and ballast maintenance
4. Electric motors maintenance
5. Incinerator operation
6. Power house operation

4.4 Low Cost/No Cost Projects

During the site survey, several low cost/no cost energy conservation opportunities were found and are listed in Table 4-5. These were grouped by project type and evaluated for cost effectiveness. Each is analyzed separately and the results are contained in Table 4-6. Detailed calculations can be found in Appendix B.

There are five basic project types:

LCNC 1: Repair Steam Leaks

LCNC 2: Turn Off Unneeded Lights

LCNC 3: Repair Steam Pipe Insulation

LCNC 4: Turn Off Steam When Not Needed

LCNC 5: Repair Leaking Compressed Air Valve

Table 4-5. Low Cost/No Cost ECOs

Area	Building Number	Low/Cost Energy Conservation Opportunities
GP	0400-00	Repair leaking steam plant whistle/horn--use compressed air for horn if possible.
FN	1606-00	Turn off exterior lights during day.
		Repair steam leak on northwest corner of the building (next to elevator motor house).
SR	1610-00	Turn off exterior lights during day.
FN	1665-00	Turn off exterior lights during day.
FN	1674-00	Repair leaking steam valve to hot water converter No. 1.
NC	2500-00	Repair steam leak on the outside of building.
NC	3513-00	Turn off exterior lights during day.
NC	4908-00	Insulate steam supply pipes to heater coils.
		Turn off exterior lights during day.
RK	4912-03	Turn off exterior lights during day.
RK	4912-07	Repair missing steam pipe insulation on the west end of building, north side of motor house and to the bay heater.
		Repair leaking steam valve to bay heater.
RK	4912-11	Replace/repair missing steam line insulation in air conditioning house.
RK	4912-15	Turn off exterior lights during day.
MF	4912-34	Turn off exterior lights during day.
MF	4912-40	Repair steam leak in preheat pipe on north side of motor/heater house.
		Insulate exterior steam pipes to heater and preheat coils.
MF	4912-49	Turn off exterior lights during day.
MF	4912-54	Turn off exterior lights during day.

Table 4-5. Low Cost/No Cost ECOs (Continued)

Area	Building Number	Low/Cost Energy Conservation Opportunities
RK	4915-00	Repair/close compressed air valve by the back door (outside).
RK	4919-00	Turn off exterior lights during day.
RK	4924-01	Repair leaking steam valve in back of this building.
		Insulate exterior steam pipes and valves.
		Turn off lights in mechanical room while unoccupied.
		Turn off exterior lights during day.
		Repair air leak in supply duct near heating coil.
		Replace/repair missing steam pipe insulation in mechanical room.
RK	4924-06	Repair steam leak at west end of building.
		Turn off six of the hallway lights in the M180 Reamer area.
		Turn off exterior lights during day.
NG	4932-00	Turn off exterior lights during day.
RK	5008-01	Turn off steam to radiator in vacuum pump room.
RK	7106-06	Turn off exterior lights during day.
		Repair leaking steam valve outside blower house.
RP	7113-00	Insulate hot water converter and steam lines.
		Turn off steam to radiator in hot water converter room.
		Repair leaking hot water circulating pump for even speed hot water converter #2.
		Repair/replace missing steam pipe insulation to hot water converters.

Table 4-5. Low Cost/No Cost ECOs (Continued)

Area	Building Number	Low/Cost Energy Conservation Opportunities
		Repair air leak in supply air duct at AHU.
		Turn off lights in blower house when not occupied.
RK	7801-00	Turn off lights and steam to radiators in RAAP 155 mm area (not used anymore).
RK	7804-00	Turn off exterior lights during day.
RP	9309-03	Turn off hot water or cover carpet roll/slitter table(s) when not in use, nights and weekends.
RP	9309-04	Turn off heat to roller cabinets on weekends.
		Turn off steam to radiators in the mechanical room.
RP	9334-15	Repair steam leak in front of building by the road.
		Turn off exterior lights during day.

LCNC 1 - Repair Steam Leaks

Eleven steam leaks were found at the following locations:

Area	Building Number	Low/Cost Energy Conservation Opportunities
GP	0400-00	Repair leaking steam plant whistle/horn--use compressed air for horn if possible.
FN	1606-00	Repair steam leak on northwest corner of the building (next to elevator motor house).
FN	1674-00	Repair leaking steam valve to hot water converter No. 1.
NC	2500-00	Repair steam leak on the outside of building.
RK	4912-07	Repair leaking steam valve to bay heater.
MF	4912-40	Repair steam leak in preheat pipe on north side of motor/heater house.
RK	4924-01	Repair leaking steam valve in back of this building.
RK	4924-06	Repair steam leak at west end of building.
RK	7106-06	Repair leaking steam valve outside blower house.
RP	7113-00	Repair leaking hot water circulating pump for even speed hot water converter #2.
RP	9334-15	Repair steam leak in front of building by the road.

Generally, the leaks were at valves which would require replacement. However, because leaking steam is so costly, this is a cost effective project.

Cost

Manhours (pipefitter)	$ 44
Labor	642
Materials	9,000
Total	9,642

Savings

Energy (Coal)	7,260 MBtu/year
Cost	$5,584/year

3/91

LCNC 1 - Repair Steam Leaks

Eleven steam leaks were found at the following locations:

Area	Building Number	Low/Cost Energy Conservation Opportunities
GP	0400-00	Repair leaking steam plant whistle/horn--use compressed air for horn if possible.
FN	1606-00	Repair steam leak on northwest corner of the building (next to elevator motor house).
FN	1674-00	Repair leaking steam valve to hot water converter No. 1.
NC	2500-00	Repair steam leak on the outside of building.
RK	4912-07	Repair leaking steam valve to bay heater.
MF	4912-40	Repair steam leak in preheat pipe on north side of motor/heater house.
RK	4924-01	Repair leaking steam valve in back of this building.
RK	4924-06	Repair steam leak at west end of building.
RK	7106-06	Repair leaking steam valve outside blower house.
RP	7113-00	Repair leaking hot water circulating pump for even speed hot water converter #2.
RP	9334-15	Repair steam leak in front of building by the road.

Generally, the leaks were at valves which would require replacement. However, because leaking steam is so costly, this is a cost effective project.

Cost

Manhours (pipefitter)	$ 44
Labor	642
Materials	9,000
Total	9,642

Savings

Energy (Coal)	8,525 MBtu/year
Cost	$13,725/year

LCNC 2 - Turn Off Unneeded Lights

Numerous instances were found where exterior lights were left on in the daytime and lights were left on in unoccupied areas. Close attention to the simple procedure of turning these lights off can save money with no capital or labor expense. The list of occurrences are shown below.

Area	Building Number	Low/Cost Energy Conservation Opportunities
FN	1606-00	Turn off exterior lights during day.
SR	1610-00	Turn off exterior lights during day.
FN	1665-00	Turn off exterior lights during day.
NC	3513-00	Turn off exterior lights during day.
NC	4908-00	Turn off exterior lights during day.
RK	4912-03	Turn off exterior lights during day.
RK	4912-15	Turn off exterior lights during day.
MF	4912-34	Turn off exterior lights during day.
MF	4912-49	Turn off exterior lights during day.
MF	4912-54	Turn off exterior lights during day.
RK	4919-00	Turn off exterior lights during day.
RK	4924-01	Turn off lights in mechanical room while unoccupied.
		Turn off exterior lights during day.
RK	4924-06	Turn off six of the hallway lights in the M180 Reamer area.
		Turn off exterior lights during day.
NG	4932-00	Turn off exterior lights during day.
RK	7106-06	Turn off exterior lights during day.
RP	7113-00	Turn off lights in blower house when not occupied.
RK	7801-00	Turn off lights and steam to radiators in RAAP 155 mm area (not used anymore).
RK	7804-00	Turn off exterior lights during day.
RP	9334-15	Turn off exterior lights during day.

Cost

None

Savings

Electricity	43,800 kwh/year 150 MBtu/year
Cost Savings	$1,325/year

LCNC 3 - Repair Steam Pipe Insulation

Steam line insulation was found missing in the following locations:

Area	Building Number	Low/Cost Energy Conservation Opportunities
NC	4908-00	Insulate steam supply pipes to heater coils.
RK	4912-07	Repair missing steam pipe insulation on the west end of building, north side of motor house and to the bay heater.
RK	4912-11	Replace/repair missing steam line insulation in air conditioning house.
MF	4912-40	Insulate exterior steam pipes to heater and preheat coils.
RK	4924-01	Insulate exterior steam pipes and valves.
RK	4924-01	Replace/repair missing steam pipe insulation in mechanical room.
RP	7113-00	Insulate hot water converter and steam lines.
RP	7113-00	Repair/replace missing steam pipe insulation to hot water converters.

Repairing these problems will save energy and dollars.

Cost

Manhours	$ 45
Labor	$ 802
Materials	$ 855
Total	$1,657

Savings

Energy (Coal)	342 MBtu/year
Cost Savings	$263/year

LCNC 4 - Turn Off Steam When not Needed

Steam was found supplying certain areas where it was not needed. These are listed below:

Area	Building Number	Low/Cost Energy Conservation Opportunities
RK	5008-01	Turn off steam to radiator in vacuum pump room.
RP	7113-00	Turn off steam to radiator in hot water converter room.
RP	9309-03	Turn off hot water or cover carpet roll/slitter table(s) when not in use, nights and weekends.
RP	9309-04	Turn off heat to roller cabinets on weekends.
		Turn off steam to radiators in the mechanical room.

The vacuum pump room, mechanical rooms and hot water converter room should be turned to their lowest settings in the winter and off during nonheating periods. The other, operational areas could be turned off in the nonheating seasons on the weekends.

Cost

None

Savings

Energy (Coal)	382 MBtu/year
Energy Cost	$296/year

LCNC 5 - Repair Leaking Compressed Air Valve

A valve was found leaking near the rear door of Building 4915-00. Repair or replacing this valve would save in compressed air energy costs.

Area	Building Number	Low/Cost Energy Conservation Opportunities
RK	4915-00	Repair/close compressed air valve by the back door (outside).

Cost

Manhours	2 hours
Labor	$36
Materials	$50
Total	$86

Savings

Energy (Electricity)	24,550 kwh/year 84 MBtu/year
Energy Cost	$742/year

Table 4-6. Low Cost/No Cost Projects

Number	Cost	Energy Savings (MBtu/year) Coal	Energy Savings (MBtu/year) Electric	Cost Savings
LCNC-1	$11,785	7,260	--	$5,584
LCNC-2	--	--	150	1,325
LCNC-3	1,657	342	--	263
LCNC-4	--	384	--	296
LCNC-5	86	--	84	742
TOTALS	$11,528	7,986	234	$8,210

LCNC-1 = Repair steam leaks
LCNC-2 = Turn of unneeded lights
LCNC-3 = Repair steam pipe insulation
LCNC-4 = Turn off steam when not needed
LCNC-5 = Repair leaking compressed air valve

5.0 ENERGY PLAN

5.1 Project Packaging

The ECOs listed in Table 4-2 were evaluated for appropriate funding category. The project scope of work listed the following guidelines on this subject.

	Project Cost	Simple Payback
QRIP	< $100,000	≤ 2 yrs.
OSD PIF	> $100,000	≤ 4 yrs.
PECIP	> $ 3,000	≤ 4 yrs.
ECAM	---	≤ 10 yrs., SIR > 1.0

AMCCOM provided the following changes for AMC installations in general and to be used for Radford AAP.

	Project Cost	Simple Payback
QRIP	$5,000-$100,000	≤ 2 yrs.
OSD PIF	> $100,000	≤ 4 yrs.
PECIP	> $100,000	≤ 4 yrs.
ECAM	---	≤ 10 yrs., SIR > 1.0

Form 1391 is required only for those ECAM projects costing greater than $200,000.

Table 5-1 contains the results of the analysis with the project funding category listed in the far right column. Projects GP-W-1 and NC-U-1 were not recommended because of safety concerns of RAAP Safety Division. Table 5-2 lists the ECOs by project funding category.

Based on guidance from Hercules Project Administration, the QRIP and OSD PIF forms were completed and are found in Volume IV. Those ECOs qualifying for ECAM funding are submitted by RAAP on an annual basis under the program named Production Support and Equipment Replacement. For ECAM projects, Radford requested that only the project discussion, economic analysis and calculations backup be provided.

Table 5-1. Results Of ECO Evaluations - Project Funding

#	ECO #	Construction Cost Plus SIOH	Savings (Increase), MBtu/Year Elec	Coal	Dist	N Gas	Net Cost Savings	Simple Payback	SIR	Project Funding
1	GP-X-3	***	0	0	18,572	0	$79,300	***	***	-
2	GP-X-1	***	0	0	18,308	0	$78,175	***	***	-
3	GP-X-2	$14,830	0	0	3,942	0	$16,832	0.84	20.36	QRIP
4	SR-I-1	$17,932	1,576	0	0	0	$13,979	1.22	7.20	QRIP
5	NC-X-1	$122,374	0	123,431	0	0	$94,927	1.23	8.97	QRIP
6	GP-N-3	$22,667	1,024	0	0	0	$15,770	1.37	6.52	QRIP
7	GP-W-1	$19,251	0	16,055	0	0	$12,348	1.48	3.00	NR
8	GP-X-4	$40,512	2,480	0	0	0	$21,998	1.67	6.83	QRIP
9	GP-N-1	$132,467	4,003	0	0	0	$65,833	1.91	4.67	OSD PIF
10	GP-B-4	$195,266	10,940	0	0	0	$96,994	1.91	4.59	OSD PIF
11	GP-N-2	$13,766	371	0	0	0	$6,416	2.04	4.38	ECAM
12	GP-X-6	$263,750	0	0	86,217	(86,217)	$78,457	3.20	4.80	OSD PIF
13	GP-D-2	$1,529,750	-695	215,204	0	0	$340,000	4.28	3.13	NR
14	GP-N-8	$155,150	2,354	0	0	0	$31,081	4.80	1.87	ECAM
15	FN-U-1	$52,643	0	12,258	0	0	$9,427	5.31	2.07	ECAM
16	GP-D-1	$289,627	0	24,475	0	0	$39,876	6.91	1.45	NR
17	GP-N-4	$8 **	0.13	0	0	0	$1	7.38	0.35	NR
18	GP-N-6	$533 **	2	0	0	0	$44	11.40	1.01	NR
19	GP-X-5	$42,488	0	4,602	0	0	$3,540	11.42	1.33	NR
20	NC-U-1	$70,271	0	6,674	0	0	$5,133	13.02	0.84	NR
21	GP-B-1	$1,737,092	12,827	0	0	0	$113,724	14.53	0.78	NR
22	GP-N-5	$87 **	0.58	0	0	0	$5	16.16	0.70	NR
23	GP-N-7	$59 **	0.39	0	0	0	$4	16.30	0.69	NR
24	FN-U-2	$45,905	0	2,822	0	0	$2,170	20.12	0.75	NR
25	MF-X-1	$64,219	0	706	0	0	$933	65.50	0.16	NR
26	GP-N-9	$1 *	0.13	0	0	0	$1	0.70	--	-
27	GP-N-10	$7 *	0.28	0	0	0	$2	2.70	--	-
28	GP-B-2	$369-$7,596 *	10-177	0	0	0	$85-$1600	2.9-5.8	--	-
29	GP-B-3	$580-$13,293 *	10-171	0	0	0	$85-$1513	5.2-9.0	--	-

* On a per unit basis at time of failure.

** On a per unit basis.

*** A low cost/no cost adjustment. However, a new incineration permit may be required.

Table 5-2. Project Funding List

QRIP

- GP-X-2 - Reduce Water Flow to Incinerator (one unit only)
- SR-I-1 - Remove Steam Coils in Activated Carbon Area
- GP-N-3 - Replace Exterior Incandescents with Fluorescents
- GP-X-4 - Install Turning Vanes in Boiler Ductwork
- NC-X-1 - Modify Boiling Tub Heating Method (one tub only)

OSD PIF

- GP-B-4 - Install Variable Frequency Drives
- GP-N-1 - Replace Incandescents with 35W HPS Screw-Ins
- GP-X-6 - Change Incinerator Fuel to Natural Gas

ECAM

- FN-U-1 - Cover Water Dry Tanks with Insulating Spheres (one tank only)
- GP-N-8 - Replace Incandescents with Color-Corrected HPS Screw-Ins
- GP-N-2 - Replace Incandescents with Circline Fluorescents

5.2 Energy and Cost Savings

Energy and cost savings for the recommended project funding are listed in Table 5-3. The implementation of all projects yield a total annual energy savings of 160,023 MBtu and annual cost savings equal to $420,633. Low cost/no cost adjustments in the waste propellant incinerator (projects GP-X-1 and GP-X-3 in Table 4-4) yield another 36,880 MBtu and $157,475 annual energy and cost savings, respectively. This totals to 196,903 MBtu and $578,108 annual savings, which represents reductions of 4.7 percent and 6.0 percent, respectively. Figures 5-1 and 5-2 show energy use and cost, respectively, at Radford AAP before and after implementation of these projects.

5.3 Project Schedule

Hercules Project Administration provided the following project implementation dates:

QRIP, OSD PIF and PECIP	FY92 (at earliest)
ECAM	FY95

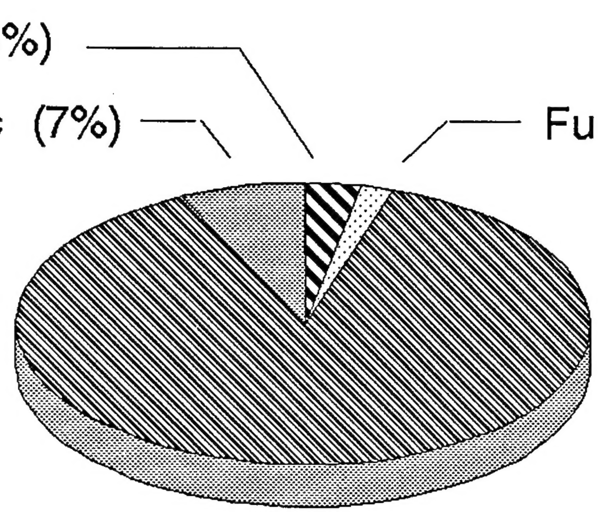
Following this schedule, Figure 5-3 was developed to show the impact implementation the recommended projects would have on energy use at RAAP. QRIPs for one unit only would be implemented in FY92 with the remainder in FY95.

5-3. Project Energy and Cost Savings

#	ECO #	Construction Cost Plus SIOH	Savings (Increase), MBtu/Year				Net Cost Savings	Simple Payback	SIR	Project Funding	PROGRAM YEAR (FY)	ESC'D COST
			Elec	Coal	Dist	N Gas						
1	NC-X-1a	$9,413	0	11,221	0	0	$8,630	1.23	8.97	QRIP (1)	92	$10,692
2	GP-X-2a	$7,415	0	0	1,971	0	$8,416	0.84	20.36	QRIP (1)	92	$8,422
3	SR-I-1	$17,932	1,576	0	0	0	$13,979	1.22	7.20	QRIP	92	$20,367
4	GP-N-3	$22,667	1,024	0	0	0	$15,770	1.37	6.52	QRIP	92	$25,745
5	GP-X-4	$40,512	2,480	0	0	0	$21,998	1.67	6.83	QRIP	92	$46,014
6	GP-N-1	$132,467	4,003	0	0	0	$65,833	1.91	4.67	OSD PIF	92	$150,456
7	GP-B-4	$195,266	10,940	0	0	0	$96,994	1.91	4.59	OSD PIF	92	$221,783
8	GP-X-6	$263,750	0	0	86,217	(86,217)	$78,457	3.20	4.80	OSD PIF	92	$299,567
9	GP-N-2	$13,766	371	0	0	0	$6,416	2.04	4.38	ECAM	95	$17,191
10	FN-U-1a	$3,290	0	766	0	0	$589	5.31	2.07	ECAM (1)	95	$4,109
11	GP-N-8	$155,150	2,354	0	0	0	$31,081	4.80	1.87	ECAM (3)	95	$193,752
12	NC-X-1b	$112,960	0	112,210	0	0	$86,300	1.23	8.97	QRIP (2)	95	$141,065
13	GP-X-2b	$7,415	0	0	1,971	0	$8,416	0.84	20.36	QRIP (2)	95	$9,260
14	FN-U-1b	$49,353	0	11,490	0	0	$8,835	5.31	2.07	OSD PIF (2)	95	$61,632
	TOTALS	$1,031,356	22,748	135,687	90,159	(86,217)	$420,633	--	--	-	-	$1,016,303

1 Partial funding (for one unit only).
2 Funding for remaining units.
3 Alternate for GP-N-1. Costs and savings are not included in totals.

Radford Army Ammunition Plant
After Project Implementation

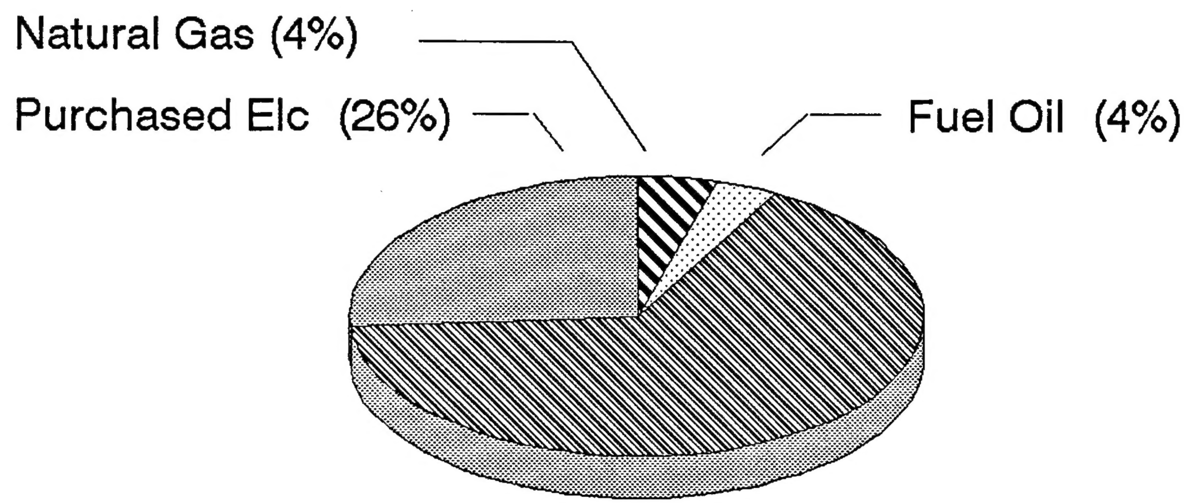


Total Use = 3,980,373 MBtu

Does not include mobility fuels.

Figure 5-1

Radford Army Ammunition Plant
After Project Implementation



Total Cost = $ 9,077,770

Does not include mobility fuels.

Figure 5-2

Radford Army Ammunition Plant

Effects of Energy Projects

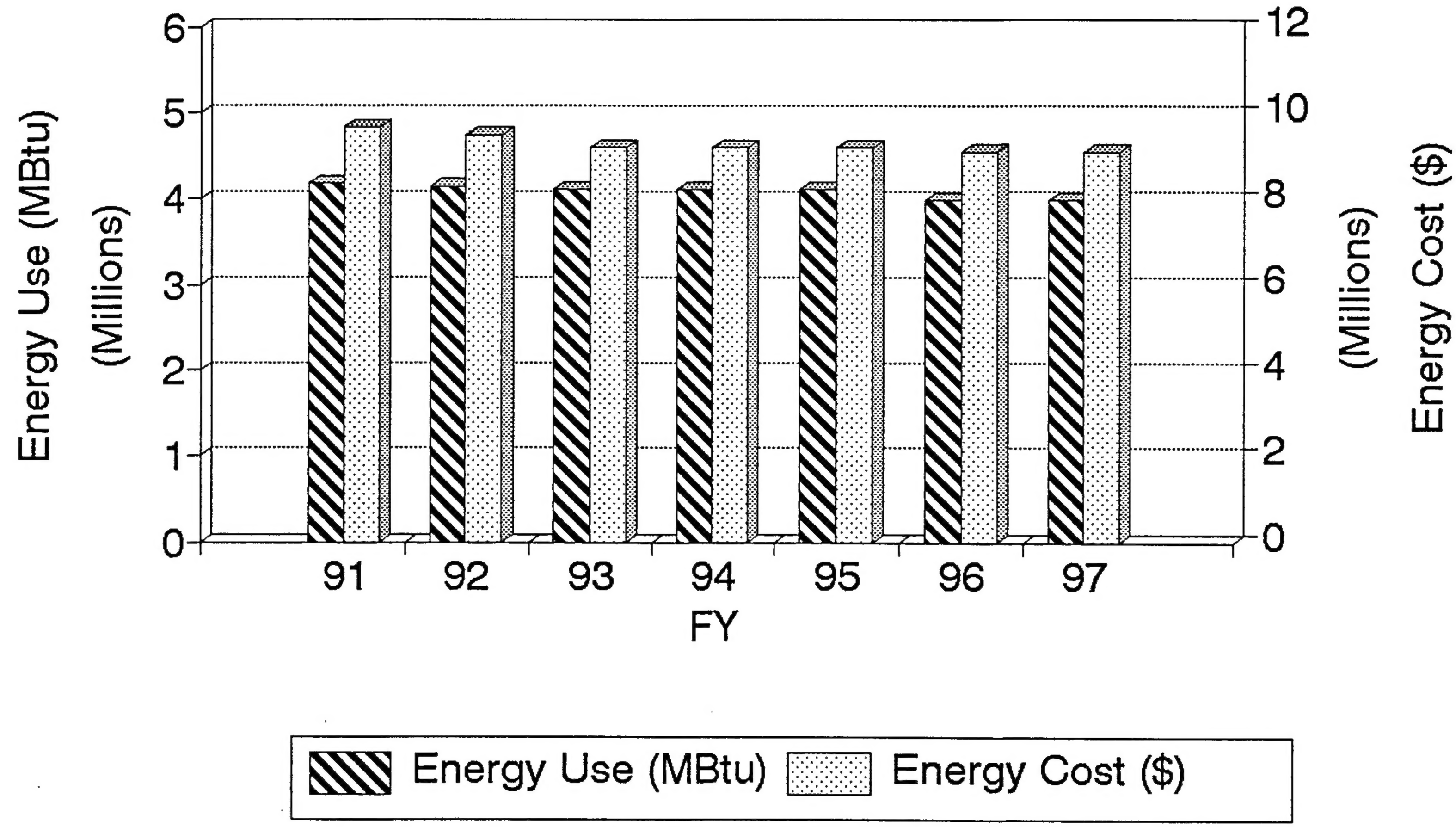


Figure 5-3